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FINCH, PRUYN AND COMPANY, INC.

GLENS FALLS HYDROELECTRIC PROJECT

**REPORT ON FISH ENTRAINMENT STUDY
NOVEMBER 1993 TO NOVEMBER 1994**

VOLUME I

FERC NO. 2385-002

P08475.29.50

JANUARY 1995

ACRES INTERNATIONAL CORPORATION
140 John James Audubon Parkway
Amherst, New York 14228-1180



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January 27, 1995
P8475.21.01
T.360

Ms. Lois D. Cashell
Secretary
Federal Energy Regulatory Commission
825 North Capitol Street, N.E. Room 3100
Washington, DC 20426

Dear Ms. Cashell:

GLENS FALLS HYDROELECTRIC PROJECT
FERC No. 2385-002
FISH ENTRAINMENT STUDY REPORT

Please find enclosed for filing, an original and 8 copies of the document entitled, "Report on Fish Entrainment Study, November 1993 to November 1994". This report is filed on behalf of Finch, Pruyn and Company, Inc. (Finch, Pruyn), Applicant for relicensing of the existing Glens Falls Hydroelectric Project (FERC No. 2385-002). This filing is made in response to a FERC staff Additional Information Request (AIR) dated February 10, 1993, in which the staff requested that Finch, Pruyn either:

1. develop an enhancement plan for minimizing impingement and entrainment of fishes at the project; or
2. conduct a study to determine the effects of the project on the fisheries of the Hudson River Basin.

Finch, Pruyn elected to conduct a fish entrainment study, although conditions at the Glens Falls Project did not allow a study to be conducted at that site. After negotiation and agreement with the State and Federal fishery agencies, Finch, Pruyn participated in a joint study at the upstream Feeder Dam Project (FERC No. 2554-003), and the results from the Feeder Dam study were applied to the Glens Falls Project. The joint study plan was filed with FERC on May 10, 1993. The FERC approved the study plan on July 23, 1993, and required that the study be completed within 18 months (by January 23, 1995). The enclosed report describes the results of the joint fish entrainment study, with application of the results to the Glens Falls Project.

The February 10, 1993 staff AIR also required that even if Finch, Pruyn elected to conduct a study, the final report should also include "...an enhancement plan to minimize the entrainment and impingement of fishes, a schedule for implementation of this plan, and a cost estimate". Accordingly, the enclosed report evaluates enhancement plan alternatives, comparing their installation costs with the value of fish that would be protected.

Based on the results of the fish entrainment study, which documented that fish entrainment and mortality is low at the Glens Falls Project, Finch, Pruyn has concluded that fish protective structures are not justified at the Glens Falls Project. Thus, Finch, Pruyn's enhancement plan is to make an annual payment to the State of New York equal to the annual value of fish killed during passage through the powerhouse. This payment can in turn be used by the State in stocking programs, other programs to enhance recreational fishing opportunities in the State, or in any manner desired by the State.

ACRES INTERNATIONAL CORPORATION
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January 27, 1995

It is proposed that these payments begin the same year that a new FERC license is issued for the project. The exact amount of these payments must still be negotiated with the State and Federal fishery agencies, since there currently is disagreement on the value of fish to use in assessing the value of fish "lost". Finch, Pruyn is proposing that the fish values be based on values published by the American Fisheries Society. The overall cost of this program over the full license term cannot yet be estimated, however, since the amount of the annual payment has not been established.

If the FERC staff has any questions on this filing, please do not hesitate to contact me at (716)689-3737, or Mr. David Manny at Finch, Pruyn and Company, Inc. at (518)793-2541.

On Behalf of Finch, Pruyn and Company, Inc.

Sincerely,



Robert Eggink
Project Manager

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EXECUTIVE SUMMARY

Finch, Pruyn and Company, Inc., Applicant for relicensing of the existing 12-MW Glens Falls Project (FERC No. 2385-002), has conducted a joint fish entrainment study, in response to a FERC staff Additional Information Request (AIR) dated February 10, 1993. The joint study was conducted at the upstream Feeder Dam Project (FERC No. 2554-003) from October 1993 to November 1994. The study utilized tailrace netting to estimate fish entrainment through the Feeder Dam Project, with the results to be applied to the Glens Falls Project. As agreed upon with the state and federal fishery agencies, tailrace netting was conducted on two of the total of five Feeder Dam generating units, on a biweekly basis for one year. Net efficiency and turbine mortality studies were conducted in October/November 1993 and May/June 1994. Tailrace netting was conducted throughout the winter of 1993-1994, with the exception of one sample event in January and one event in February, which were canceled due to adverse weather conditions. Sample events ranged from 24 to 48 hours in duration, depending on the season.

Total station daily entrainment at Feeder Dam was extrapolated by calculating the number of fish per volume of flow sampled, and multiplying this value by the total volume of flow passing the station, as recorded by a computerized data logging system. Total annual entrainment was calculated by adding the estimated entrainment for all sample periods (a sample period was usually 7 days before and 7 days after a sample event) through the year. Mortality at the project was estimated by using mortality rates determined during the spring, 1994 mortality tests. These rates ranged from about 2 percent to 17 percent, depending on the species and size group.

The Feeder Dam results were utilized to estimate entrainment and mortality at the Glens Falls Project by:

- (1) Screening the Feeder Dam raw catch database by excluding fish with widths greater than 1-5/8 inches, to reflect the narrower rack spacing at Glens Falls;
- (2) Applying the "screened" fish per volume values from Feeder Dam to the volume representing 50 percent of the flow passing the Glens Falls site, to reflect the 50-50 sharing of flow with the South Glens Falls Project; and
- (3) Developing and applying a mortality adjustment factor (2.32) to adjust the mortality rates determined at Feeder Dam to reflect the conditions at Glens Falls Project (higher head and different unit type).

An estimated 38,746 fish representing 29 species were entrained at the Glens Falls Project during the one-year study period. Peak entrainment occurred during the month of June, with the lowest entrainment in January. The catch was dominated by centrarchids (primarily rock bass and redbreast sunfish), bullheads/catfishes, yellow perch, and minnows. Primary game species entrained (in descending order of abundance) included: largemouth bass, smallmouth bass, rainbow trout, brown trout, walleye, and northern pike. Game species, however, generally accounted for only a small portion of the catch. Based on the adjusted mortality rates determined at Feeder Dam, an estimated 6,807 fish were killed during turbine passage. Using fish values published by the American Fisheries Society, this estimated annual mortality is worth \$9,402.

This estimated annual value of fish losses was compared to the estimated costs of installing and operating fish protection structures. Five structural alternatives for fish protection were evaluated, with estimated construction costs ranging from \$1,202,000 to \$2,420,000, and annual energy losses of \$27,000 to \$68,200. Based on this economic comparison and on the study results that indicate fish entrainment mortality at the Glens Falls Project is minor, fish protective structures are not warranted and should not be constructed.

1 INTRODUCTION

On December 4, 1991, Finch, Pruyn and Company, Inc. (Finch, Pruyn) filed an application for a new license for the existing 12-MW Glens Falls Project (FERC No. 2385-002), located on the Hudson River in Glens Falls, New York. In response to this application, on August 28, 1992, FERC staff requested additional information from Finch, Pruyn, related primarily to environmental resources at the project. This additional information request, however, did not address the issue of fish entrainment at the project, which FERC staff indicated would be addressed in a later request.

This later request was made by FERC staff on February 10, 1993. In this request, the staff stated that Finch, Pruyn must either:

- (1) develop an enhancement plan for minimizing impingement and entrainment of fishes at the project; or
- (2) conduct a study to determine the effects of the project on the fisheries of the Hudson River Basin.

Finch, Pruyn chose the fish entrainment study option, and the study was conducted as a joint study at the upstream Feeder Dam Hydroelectric Project (FERC No. 2554-003). A study could not be conducted in the timeframe requested by FERC at the Glens Falls Project because of ongoing construction at the South Glens Falls Project (FERC No. 5461), and because additional time would be required to modify the Glens Falls Project tailrace structures to accommodate a study. The construction of the South Glens Falls Project also resulted in the diversion of the entire Hudson River flow through the Glens Falls Project, which was not representative of normal conditions in which each project uses 50 percent of the Hudson River flow. The Feeder Dam joint study was conducted from October 1993 to November 1994. The overall study objective was to estimate the total entrainment and mortality occurring at the Feeder Dam powerhouse for a one-year period, and apply these results to the Glens Falls Project.

The entrainment estimate at Feeder Dam would represent the maximum potential entrainment at the Glens Falls Project, since the Hudson River flow is equally shared by the Glens Falls and South Glens Falls Projects at the Glens Falls Dam. After review of the draft report during the agency consultation meeting in December 1994, however, it was agreed that entrainment at the Glens Falls Project should be estimated by using half the flow passing the Glens Falls site up to the capacity of the Glens Falls Project. The fish density per unit volume of water sampled during the Feeder Dam study was applied to the volume passing the Glens Falls Project, to estimate entrainment at the Glens Falls Project.

This report describes the methodology used during the 13-month Feeder Dam investigation, the analysis required to apply the results of the study to the Glens Falls Project, and recommendations regarding an enhancement plan for minimizing entrainment of fishes, in light of the estimated annual fish entrainment and mortality at the Glens Falls Project. Additional analyses required to adapt the Feeder Dam results to the Glens Falls Project included:

- (1) Screening the Feeder Dam database to reflect the differences in trashrack spacing between Feeder Dam (2-3/4 inches) and the Glens Falls Project (1-5/8 inches); and
- (2) Adjusting the Feeder Dam mortality rates by using the results from the 1990 RMC balloon tag mortality study at Glens Falls (RMC, 1990), to reflect the higher head and different unit type at the Glens Falls Project. These analyses are described in detail in Section 3.

This study was conducted in close coordination with the U.S. Fish and Wildlife Service (USFWS) and New York State Department of Environmental Conservation (NYSDEC). Documentation of this coordination is also included in this report.

2 APPLICANT'S APPROACH TO ANSWERING FERC REQUEST

Upon receipt of the FERC staff February 10, 1993 request, Finch, Pruyn began an evaluation of the potential costs and benefits of the two options presented by FERC staff. Finch, Pruyn retained Acres International Corporation to:

- (1) Develop conceptual designs and cost estimates for potential fish protection structures at the Glens Falls Project, based on the most recent recommendations of the USFWS and NYSDEC for other projects in New York; and
- (2) Develop a plan and cost estimate for an entrainment study at Feeder Dam, which Finch, Pruyn would partially support.

Once these conceptual plans and cost estimates were completed, Finch, Pruyn met with the USFWS and NYSDEC to discuss any possible modifications or refinements to the plans. After completing modifications to the plans based on agency comments, Acres prepared final cost estimates for the two options, and Finch, Pruyn selected the option to be proposed to FERC.

For the fish protection option, Acres developed plans for five fish protection alternatives (see Appendix A). The most expensive alternative was for an angled trashrack structure in the project forebay. This structure would have a clear spacing of one inch between the rack of bars, a maximum water approach velocity of 2 feet per second (fps), and a fish bypass at the downstream end of the racks. The estimated cost for installation of this structure was \$2.4 million in 1996 dollars (see Appendix A for breakdown of the cost estimate).

In comparison, the estimated cost for a one-year fish entrainment study at the upstream Feeder Dam, based on agency guidelines and recommendations received at that time, was about \$500,000, which would be shared with the Feeder Dam Licensee. This study would include twice per month entrainment sampling, using tailrace netting, as well as efficiency and mortality testing for selected species.

Based on this thorough evaluation of the options, and the belief that available information from other studies indicated that fish entrainment would not be significant at the Glens Falls Project or at Feeder Dam, Finch, Pruyn selected the study option. The study plan was filed with FERC on May 10, 1993, as a joint study with the licensee for the Feeder Dam project. The FERC staff approved the study plan on July 23, 1993, and preparations were initiated to begin the entrainment study by October 1993. Significant preliminary work was required at Feeder Dam, which included the construction, at a cost of about \$120,000, of access platforms and decks on the downstream side of the Feeder Dam powerhouse to allow for tailrace netting activities. Section 3 describes the study methodology in detail.

3 METHODOLOGY FOR ENTRAINMENT STUDY

This section describes the specific methodologies employed at Feeder Dam during the entrainment study, and how the study results were adapted for use in describing fish entrainment and mortality at the Glens Falls Project.

3.1 Entrainment Sampling Program

Description of the Feeder Dam and Glens Falls Projects

The Feeder Dam Project is a low-head facility located on the Hudson River 2 miles upstream of the City of Glens Falls, New York and 52 miles upstream of the Federal Lock and Dam in Troy, New York. The project dam is an uncontrolled overflow gravity structure 21 ft high and 615 ft long, and is owned by the New York State Department of Transportation (DOT). The Champlain Feeder Canal inlet structure (also owned by DOT) is located on the north abutment of the dam, and supplies water to the Feeder Canal. The project powerhouse is located at the south end of the dam and is owned by Moreau Manufacturing. The powerhouse contains five vertical fixed-blade propeller turbine units, which withdraw water from a small forebay. Water exits the powerhouse into a tailrace immediately downstream of the dam. The total hydraulic capacity of the powerhouse is about 5,000 cfs, and at a head of 16 ft, has a total generating capacity of 6 MW.

The Glens Falls Project is located 2 miles downstream of Feeder Dam in the City of Glens Falls. The project is located at the Glens Falls dam, a 500-ft-long multiple-gated structure up to 15 ft high, and jointly owned by Finch, Pruyn and the Licensee for the South Glens Falls Project. Water enters the Glens Falls Project through a 90-ft long, 30-ft-high headgate structure, and a 550-ft-long, 80-ft-wide power canal. The powerhouse is located within the Finch, Pruyn paper mill, and contains five horizontal Francis turbines with a maximum hydraulic capacity of 3,650 cfs. At a head of 46 ft, the total generating capacity is 12.1 MW. Water is discharged to the Hudson River through five tailrace tunnels that exit the side of the paper mill about 600 ft downstream of the dam.

Bi-Weekly Tailrace Netting and Schedule at Feeder Dam

Tailrace netting was conducted on a bi-weekly schedule at two units: either Unit 1 or 3 and Unit 5. Unit 1 or 3 was to represent the entrainment rate through Units 1, 2, and 3, and Unit 5 was to represent the entrainment rate for Units 4 and 5. Unit 1 or 3 were randomly selected at the start of the program and alternating units were sampled for the remainder of the project, when feasible. Unit 5 was sampled during every bi-weekly event,

with the exception of the spring high-water period which precluded normal sampling due to flooding of the Unit 5 access deck. A netting sample event consisted of either a 24- or 48-hour netting period, depending upon the season (Table 3-1). Table 3-1 displays the schedule of sample events through the one-year period.

Sampling Equipment

Each turbine unit was sampled using two tailrace nets, one for each draft tube. Under the usual scenario with two units being sampled simultaneously, four nets were required. During non-winter sampling conditions, a live car was attached to the cod end of each net, to provide a "safe" holding area for live fish collected by the net. The live car was tended at least once (usually more often) during a 24-hour period. The conceptual design of the net and live car are illustrated in Figure 3-1. Each net was constructed of 1/2-inch nylon netting, with a net mouth opening of 16.5 ft by 19.5 ft and an overall length of 50 ft. The lower 25 ft of the net (to the cod end) contained a net liner of 1/4-inch nylon netting. The 30-inch diameter cod end was either attached to the live car or cinched closed for winter collections (see below). Each live car consisted of a 1/4-inch knotless nylon netting box measuring 4 ft wide, 6 ft long, and 5 ft deep, set within a flotation frame consisting of 8-ft-long, 2-ft-wide styrofoam bat pontoons and pressure treated lumber. The live car boxes were designed to provide ample space for fish and river debris (such as leaves) that may accumulate in the net. The live car was attached to the cod end of the net via a 10-ft-long by 30-inch-wide tunnel, by combining the metal netting hoops at each attachment point and fastening with nylon tie wraps. Appendix G contains photographs illustrating the sampling techniques.

Winter Sampling Techniques

During the winter months of December, January and February, harsh weather conditions precluded sampling using the live cars and a boat and crew on the water. It was expected that significant ice build-up on the live cars would reduce their buoyancy, adversely affecting their effectiveness, and would make working conditions unsafe for the sampling crew. Thus, Acres designed an alternative sampling method in which the cod end of each of the nets was cinched or pursed, and the nets were deployed and retrieved entirely from the work decks. This technique allowed the catch to accumulate over the sample period in the cod end of the net. At the end of the sample period, the nets were retrieved back to the deck, and the net contents manually shaken down into the cod end, and emptied onto a tarp for sorting of fish and debris and later fish processing. Although live/dead fish data could not be obtained using this technique (since most fish die in the cinched cod end), entrainment abundance data could be obtained throughout the winter period.

During the months of January and February, sampling was limited to once per month, per agreement with the USFWS and NYSDEC. Data from the early-December sample event was substituted into the two events not sampled during January and February, as a conservative estimate of the mid-winter catch.

Adjustments to Technique to Improve Efficiency

As a result of the proof-of-concept and the initial net efficiency tests run in the fall of 1993, several adjustments to technique were instituted to improve the efficiency of sampling. Efficiency tests were repeated in the spring of 1994 to assess the effectiveness of the adjustments.

The following adjustments were made:

- Canvas was added the sides of each frame along the outside of the net to prevent tearing of the net resulting from abrasion caused by the rough surface of the draft tube pier nose;
- A three-inch-thick rubber gasket was attached to the bottom of the frame to facilitate a tight seal of the net frame along the sill of the draft tube;
- Wooden shims were attached to both sides of the net frame to ensure a tight and secure fit in the draft tube gate slots;
- Unit 1 was not fished during the winter months because of the rough concrete surface along the dam wall adjacent to Unit 1, which would tear holes in the net if a live car was not used (the live car tended to buoy the net away from the wall);
- An upstream cinch was installed 20 ft from the mouth of the net, which was closed just prior to pulling the net to prevent fish in the mid-body of the net from escaping during the net retrieval process; and
- The net was retrieved and net frame removed from the water under 100 percent operating gate, in an effort to force fish to remain in the net and also keep the net from collapsing into the draft tube, and spilling its contents.

Data Gathering

Information gathered during each sample event consisted of station operational data, water quality data, and fish catch data.

Station operational data were collected by an automated computer system that recorded power generation and water flow for each turbine unit and the entire station. Data were logged onto the computer every five minutes and included the instantaneous kilowatt output and calculated flow in cubic feet per second (based on the turbine efficiency curves) for each turbine unit.

Water quality data collected included Hudson River flow (as reported by Niagara Mohawk Regional Control Center), water temperature, air temperature, dissolved oxygen, conductivity, water transparency (using Secchi disc), pH, and weather conditions. These parameters were recorded at the beginning of each netting sample.

All fish collected during the tailrace netting were identified to species level if possible, measured to the nearest mm total length and to the nearest mm in width at the widest point, weighed to the nearest gram, and visually checked for general condition, fin clips, or tags. Every effort was made to return fish alive to the tailrace after processing. Fish that died during the sample program were preserved for further laboratory QA/QC checks of identifications and measurements. Table 3-2 presents the categories and descriptions of the condition codes used to record the disposition of the fish at the time of processing.

All data were recorded on standardized data sheets, field checked, encoded, entered into a computer database, and verified.

3.2 Proof-of-Concept (POC) and Net Efficiency Testing

Proof-of-Concept (POC)

The Proof-of-Concept portion of the study was conducted during the first few weeks of the project, and consisted of initial installation and testing of sampling techniques, as well as preliminary net efficiency tests. During the POC study, each tailrace was checked by a diver to ensure that the net frame was seated properly within the gate slot, and that the sampling net achieved 100 percent coverage of the turbine draft tube outflow. The diver also inspected the pier noses for obstructions that could have damaged the nets, and removed any obstructions encountered (such as exposed reinforcement rods). Results of the diver's inspection prompted installation of approximately three inches of neoprene rubber to the bottom section of each of the net frames to ensure proper net seating on the bottom of the draft tube opening. Additional measures such as installation of chaffing materials and canvas tarps along certain sections of the nets provided abrasion protection and greatly reduced tears and other damage that may have occurred during regular sample events. Improvements in the sampling procedures, as well as equipment adjustments developed during initial sampling, also enhanced the sampling process.

Net Efficiency Testing

Net efficiency tests were required to ensure that the entrainment nets were effectively collecting fish that were passing through the sampled generating units (Units 1,3 and 5), and to determine efficiency adjustment factors for the range of species collected (weak, moderate, and strong swimmers). The entrainment nets and frames were designed so that 100 percent of the discharges from a sampled unit would pass through the two nets placed on the draft tubes for each unit. Special care was taken to seal any openings around the net frame through which fish might escape. The degree of success of the nets in collecting entrained fish, however, must be known so that the adjustment factor can be applied to the net catch to calculate total entrainment.

The resource agencies had stated that minimum net efficiencies of 70 percent must be achieved before they would accept that the nets are effectively collecting entrained fish. Efficiencies of 90 percent or greater, however, were preferred by the agencies. The agencies have also indicated that efficiencies of lower than 70 percent may be acceptable, if multiple efficiency tests indicate a consistent efficiency for a particular species or size group. An appropriate correction factor could then be applied to the catch data.

Efficiency tests involved the release of a known number of marked test fish into the intake of the turbine unit to be tested, and the subsequent recovery of these test fish in the entrainment nets. Fish were released (injected) at a point upstream of the turbine runner, and in a location where fish had a high probability of being entrained and passing through the turbine. The percentage of test fish recovered over the specified period (24 or 48 hours), was assumed to reflect the collection efficiency of the nets on the tested unit. Most efficiency tests were conducted for 24 hours, and are assumed to be representative of a 24-hour netting sample.

Species used in the efficiency tests were to represent the range of species and size groups collected at the site during normal entrainment sampling. Test species were approved by the USFWS and NYSDEC, and were to represent "strong," "moderate", and "weak" swimming species. Test species included: brown trout, rainbow trout, walleye, largemouth bass, bluegill, yellow perch, and golden shiner. Table 3-3 lists the average lengths and ranges of the test species used.

The specific techniques for conducting net efficiency tests are further described.

(a) Sources of Test Fish

Test fish were obtained exclusively from a NYSDEC-approved commercial hatchery. Once test fish were delivered to the site by the commercial hatchery, they were placed in holding tanks at Feeder Dam until required for the tests. Several types of tanks were available: 100-gallon, 150-gallon and 300-gallon Rubbermaid stock tanks, 20-gallon circular tanks, and river holding pens measuring 4 feet wide by 6 feet long, and 5 feet deep. The larger tanks and river pens were generally used for larger-sized fish, while the smaller tanks were used for the smallest varieties. Species and size groups were kept in separate tanks, to prevent predation and to facilitate the marking process. The tanks were set up on either side of the forebay retaining wall near the office trailer and on the tailrace deck near Unit 5. Water was supplied from the forebay or tailrace using "Little Giant" submersible pumps and garden hose. Each tank was set up with a PVC slotted standpipe, to facilitate a single-stage flow-through system. During warmer water temperature periods later in the season, aerators were used to reduce oxygen stress.

(b) Fish Marking Procedures

Test fish were fin-clipped to later identify release location and date of release, and to differentiate test fish from naturally entrained wild fish collected in the net. Either the upper or lower caudal fin was normally clipped (using pruning shears). The upper caudal clip was used for fish released (injected) into the intake upstream of the turbine, while the lower caudal clip was used for fish released into the entrainment nets in the tailrace during fish mortality tests (see Section 3.3). Other fins (pectorals or pelvics) were also clipped to identify specific release locations (by unit) or the date of the release.

In general, fish were marked from less than 1 hour up to 4 hours prior to release, although marked fish were held longer in some circumstances. All test fish were counted and examined prior to release to ensure that the proper number were released and all fish were healthy, without obvious signs of stress, scale loss, or fungus. Fish in poor shape were eliminated from the test group and replaced with other fish of the same species and size group, if available.

(c) Fish Injection Procedures

Fish were injected either into the intake immediately downstream of the trashracks, or into the entrainment nets (for mortality tests - see Section 3.3). For fish injections at the intake, Acres designed and constructed a fish injection device

(Figure 3-2), constructed from 4-inch diameter PVC pipe. This device was lowered into the gate slot just downstream of the trashracks. Fish were then injected into either a left or right injection pipe. The design was later modified to reduce injection stress on the fish by installing a single-piece 3-inch diameter PVC pipe into the left-hand pipe, to provide smooth passage through the injector. Fish releases were then made through this left-hand pipe, using a funnel placed on the end of the pipe. Specific procedures were as follows:

- (1) A maximum of 10 to 100 marked test fish (depending on species, size, and water temperature) were placed in a 5-gallon bucket;
- (2) These fish were released through a funnel into the injection pipe;
- (3) A plunger was inserted into the injection pipe and slowly pushed into the pipe until it reached near the bottom; and
- (4) The plunger was pulled slowly out of the pipe, and if test fish had not fully exited the pipe, the plunger was re-inserted as necessary until all test fish had exited the pipe. An additional method used to ensure that all test fish had exited the pipe was to pour several buckets of water into the pipe to create a "flushing" action.

(d) Fish Recovery Procedures

Fish recovery techniques were the same as for normal entrainment sampling, since the objective was to duplicate these procedures to determine the capture (net) efficiency.

Fish were checked for fin clips, tags, or any other marks, and the information was recorded on appropriate data sheets. During "normal" (non-winter) sampling conditions, when live cars were in use, fish were removed from the live cars, sorted by species and size groups, and checked for fin clips, tags or other marks. Generally, fish taken from live cars were alive, so initial sorting usually occurred in temporary holding tubs filled with water. Many fish were captured in the body of the net and were removed when the net was pulled. Low water velocities in the tailrace and in the nets allowed fish to maintain themselves within the net during the sampling period. If these fish were promptly removed from the net when it was landed on the deck at the end of sampling, many were able to survive. During winter sampling conditions, fish were removed from the cod end of the net and also from the net body, and processed in the same manner.

Recovered test fish, if alive, were held for latent mortality testing (see Section 3.3), were held and reused in additional tests, or were released alive to the river. Live releases were made about 1 mile downstream of the dam to minimize the recapture of previous test fish through net intrusion. Dead fish were disposed of properly (buried).

(e) Data Recording/Calculation of Net Efficiency

Field data sheets were completed whenever a species or size group was released for an efficiency test. Recovery data were recorded on the same sheet after fish recoveries were made at the end of the test samples.

The net efficiency for each species/size group was calculated as follows:

$$\text{Efficiency (\%)} = \frac{\text{No. of fish recovered}}{\text{No. of fish released}} \times 100$$

3.3 Mortality Tests

An estimate of the percentage of fish that are killed while passing through the Feeder Dam Hydroelectric Station (the mortality rate) was calculated and used to estimate the total annual fish mortality attributed to operation of the station. The value of fish killed was then estimated and used in a cost benefit analysis for potential mitigative measures. A variety of fish sizes and species were tested to assess mortality rates for representative native fish species and size groups that pass through the turbines and are captured in the entrainment nets. Table 3-3 lists the species and size ranges of fish used in the mortality tests. Mortality tests were conducted in conjunction with efficiency tests. "Control" groups of fish were tested in the same numbers and species as used in the efficiency tests (the "treatment" groups). Controls were injected directly into the mouth of the entrainment nets in the tailrace, at the same time that treatment fish were injected into the turbine. Control fish experienced the same stress factors as the treatment fish, except that treatment fish passed through the turbines. Mortality tests were conducted in spring 1994 and fall 1993, when water temperatures were relatively cool (to minimize fish handling and holding stress). After treatment and control fish were recovered, surviving fish were held for an additional 24 to 48 hours to determine long-term survival/mortality.

(a) Marking and Injection Techniques

These techniques were generally the same as used in the efficiency tests. As noted previously, treatment and control fish were differentially marked. Injections into the

entrainment nets (control fish) occurred through a hand-held, 4-inch-diameter PVC pipe, inserted into the mouth of the net.

(b) **Fish Recovery and Holding Procedures**

Fish recovery procedures were the same as previously described for the efficiency tests. Live fish from mortality tests, however, were held for an additional 24 to 48 hours after net retrieval to determine long-term survival. Fish recovered from the nets and live cars were transferred via 5-gallon buckets to either spare live cars held in the Hudson River or to the 300-gallon Rubbermaid holding tanks continuously supplied with river water. Fish were generally segregated by species and size group, to prevent predation, although some species of the same size were combined and held in the same tank. Holding tanks were checked at least once every 12 hours, all dead fish were removed, identified by species and type of mark, and recorded. At the end of the holding period, any additional dead fish were removed and counted, and the remaining live fish were counted. Surviving fish were either reused in other tests or released downstream to the Hudson River.

(c) **Data Recording and Calculation of Mortality Rates**

A mortality rate was calculated for each species and size group by first determining the survival of treatment fish (released through the turbine), and then adjusting this survival by the control fish (released into the entrainment net) survival. The estimated mortality rate is calculated as 1.00 minus the adjusted survival.

The calculations are as follows:

- Treatment fish unadjusted survival =

$$\frac{\text{Treatment fish recovered live}}{\text{Total No. of treatment fish recovered}}$$

- Control fish survival =

$$\frac{\text{Control fish recovered live}}{\text{Total No. of control fish recovered}}$$

- Adjusted fish survival =

$$\frac{\text{Treatment fish unadjusted survival}}{\text{Control fish survival}}$$

- Mortality rate =

$$1.00 - \text{Adjusted fish survival}$$

Long-term survival/mortality was calculated as follows:

- Unadjusted treatment-fish 24-hour or 48-hour survival =

$$\frac{\begin{array}{l} \text{Treatment fish initially recovered live} \\ - \text{treatment fish dead after 24 or 48 hours} \end{array}}{\text{Total number of treatment fish recovered}}$$

- Control fish 24-hour or 48-hour survival =

$$\frac{\begin{array}{l} \text{Control fish initially recovered live} \\ - \text{control fish dead after 24- or 48 hours} \end{array}}{\text{Total number of control fish recovered}}$$

- Adjusted 24-hour or 48-hour fish survival =

$$\frac{\text{Unadjusted treatment fish 24- or 48-hour survival}}{\text{Control fish 24- or 48-hour survival}}$$

- Long-term mortality rates =

$$1.00 - \text{Adjusted 24- or 48-hour fish survival}$$

It was anticipated that mortality rates would be determined for "immediate", "24-hour", and "48-hour" test intervals. Many treatment and control fish, however, did not immediately move into the live cars after injection, where they could quickly be collected. Thus, it became evident that the "immediate" test interval would not be obtained. Since many fish are not recovered until the nets are pulled (24 hours after fish injection), mortality rates can only be determined 0 hours, 24 hours, and 48 hours after net retrieval. Thus, 0-hours mortality is actually the mortality rate at time 24 hours after injection, when all test fish that were captured in the live car or body of the net are accounted for. To be consistent with other ongoing New York State studies, however, the 0-hours mortality will be reported as "immediate" mortality, and longer-term mortality will be reported as "24-hours" and "48-hours."

3.4 Data Analysis and Entrainment Mortality Estimates for Application to the Glens Falls Project

General Description of Program

The goal of the study was to assess the fish entrainment at the Feeder Dam Hydroelectric Project for the one-year study period, and adjust the results for conditions at the Glens Falls Project to obtain estimates of entrainment at the Glens Falls Project. To estimate annual entrainment at Feeder Dam, full turbine outflow netting was conducted during all four seasons, using three different turbine units representing two turbine groupings. Sampling was scheduled to occur on a bi-weekly basis for a full calendar year starting in October 1993. A netting sample was conducted for a 24- or 48-hour period of time. During winter months (January and February) sampling was scaled back and conducted on a once-per-month schedule, per agreement with the agencies. Each of the sample events represented a period of time referred to as a sample period. The sample period consisted of the number of days surrounding a sample event and divided evenly between events (approximately 14 days).

To account for differential netting efficiencies and turbine passage mortality, entrainment samples were categorized by species and size group. The categories were dependent on the results from the net efficiency and mortality tests described in the previous sections.

Estimated sample entrainment was adjusted according to the efficiency rates obtained from the tests, and the corrected sample entrainment was expanded to obtain station entrainment for the sample period.

Entrainment Data Expansions for Feeder Dam

The step-by-step process from field collection to annual estimates of entrainment are traced with the flow diagram (Figure 3-3) and by the formulas listed in Table 3-4.

Basic assumptions for the expansion methodology, as agreed to with NYSDEC and USFWS personnel, were as follows:

- Samples collected from turbine Units 1 or 3 are used to represent entrainment in Units 1, 2 and 3;
- Samples collected from turbine Unit 5 are used to represent entrainment in Units 4 and 5;

- Entrained fish species are separated into 25-mm size intervals; and
- Entrained fish species are represented by specific test fish species/size groups used during efficiency and mortality studies (i.e., strong, moderate, and weak swimmers; body types, and size groups small, medium and large).

Briefly, the entrainment expansion methodology involves the following steps (also see Figure 3-3):

- (1) The numbers of fish collected in entrainment samples (for a 24-hr period), are adjusted by the net efficiency rates for each species/size group;
- (2) The density of fish per unit volume of flow sampled is determined by dividing the number of fish calculated in step (1) by the volume of water passed by the sampled unit (Units 1, 3, or 5);
- (3) The number of fish entrained by Units 1, 2, and 3 are calculated by multiplying fish per unit volume for Units 1 or 3 (whichever is sampled) by the total volume passed by Units 1, 2 and 3 during the 24-hr sample period;
- (4) The number of fish entrained by Units 4 and 5 are calculated by multiplying fish per unit volume for Unit 5 by the total volume passed by Units 4 and 5 during the 24-hr sample period;
- (5) The total number of fish entrained at Feeder Dam for the 24-hr sample period is the addition of the estimates from steps (3) and (4);
- (6) The number of days represented by each 24-hr sample is calculated by determining the number of days midway between the preceding and following sample event (generally 7 days before and 7 days after the sampling date);
- (7) The total entrainment for the approximately 14-day sample period is calculated by multiplying the number of fish determined in step (5) by the number of days determined in step (6); and
- (8) The total annual entrainment is calculated by adding the estimated entrainment for all sample periods.

Estimates of Mortality and Value of Fish Killed at Feeder Dam

Once the total station entrainment was calculated for the entire year, the mortality rates for turbine passage determined through the mortality tests were applied (on a species and size group basis), to estimate the total annual number of fishes killed by the project as a result of turbine passage.

To estimate the value of fishes killed by the project, the American Fisheries Society (AFS), 1992 publication entitled, "Investigation and Valuation of Fish Kills" (Special Publication 24) was utilized to develop a fish value database (by species and size group). One species, rainbow smelt, was not included in the AFS publication. The value for this species was based on the retail price for fresh whole smelt in a Western New York supermarket chain (Wegman's). The fish value database was applied to the annual estimates of mortality (by species and size group), to estimate the value of fish lost.

Application of Feeder Dam Results to Glens Falls Project

The Glens Falls Project is located on the Hudson River only two miles downstream of the Feeder Dam Project, and thus the fish species composition of the two project areas is virtually identical. The project configurations and operations, however, differ, and thus the Feeder Dam results must be modified to reflect the project differences.

These differences include:

- (1) The Glens Falls Project utilizes only 50 percent of the Hudson River flow passing the project (the other 50 percent is used by the South Glens Falls Project);
- (2) The trashrack spacing at Feeder Dam is 2-3/4 inches, while the trashrack spacing at the Glens Falls Project is 1-5/8 inches;
- (3) Feeder Dam has vertical propeller units, and Glens Falls has horizontal Francis units; and
- (4) The head at Feeder Dam is 15.5 ft, while the head at Glens Falls is 46 ft.

The following data manipulations were required to apply the Feeder Dam test results to the Glens Falls Project:

- (1) The entrainment database was screened to remove fish with body widths of greater than 1-5/8 inches (41 mm), since these fish could not physically pass through the Glens Falls trashracks;
- (2) The volume of flow passing the Glens Falls site during the course of the Feeder Dam study was estimated, and the 50 percent share for the Glens Falls Project was calculated;
- (3) The fish per unit volume of flow passing Feeder Dam (after screening for 1-5/8 inch racks) was applied to the estimated volume of flow passing the Glens Falls Project, to estimate entrainment; and
- (4) The mortality rates determined at Feeder Dam were adjusted to reflect the higher head and different unit type at Glens Falls, and the adjusted rates were applied to the Glens Falls estimated entrainment to calculate mortality at Glens Falls.

Item (1) was accomplished by manipulating the Feeder Dam database to remove any fish with measured widths greater than 41 mm. For Item (2), flow records of the USGS, Niagara Mohawk, and Finch, Pruyn were used to determine the river flow passing the Glens Falls Dam during the days that entrainment sampling occurred at Feeder Dam. Fifty percent of the average daily flow was estimated, and the total volume of flow (in cubic feet) passing the Glens Falls Project was calculated as follows:

- Average daily flow x .50 = Flow entering the Glens Falls Project (up to the maximum project hydraulic capacity of 3,650 cfs); and
- Glens Falls Project flow x 86,400 seconds = Volume of flow passing the project in 24 hours.

The fish per unit volume of flow passing Feeder Dam [Item (3)] was calculated by combining the catch from both units sampled at Feeder Dam on each sample date (after screening for 1-5/8 inch-spaced racks), and dividing by the total volume passed by the two units during the sample event. This fish per unit volume was then applied to the estimated volume of flow passing the Glens Falls Project [Item (2)] to estimate the daily entrainment at the Glens Falls Project. This estimated daily entrainment was multiplied by the number of days in the total sample period represented by the daily estimate (usually 14 days) to determine entrainment for the sample period. The results from all the sample periods in the year were combined to produce the annual estimated entrainment.

The adjustment factor for mortality rates [Item (4)] was developed by comparing the long-term (24-hour) mortality rates determined for largemouth bass (6 to 12 inches in length) at Feeder Dam, and the long-term (24-hour) mortality rates determined for similar-sized smallmouth bass at the Glens Falls Project in the 1990 balloon-tag study (RMC, 1990). The 24-hour rates were used for this comparison because 24-hour rates are being used in the mortality calculations at Feeder Dam. More "successful" mortality tests were available at 24 hours versus 48 hours of holding for latent mortality. The steps in calculating the adjustment factor were as follows:

- The 24-hour mortality rates (adjusted for controls) were calculated for smallmouth bass at Glens Falls, from RMC data, using the same calculation methods as used in the Feeder Dam studies. The results were:

Tested Unit at Glens Falls	24-hour Mortality Rate
4	41.8%
5	24.6%
Weighted Station Average*	34.93%

*Unit 4 represents three units and Unit 5 represents two units, based on unit type (quadriplex vs duplex).

- The Feeder Dam 24-hour adjusted mortality rates for largemouth bass were calculated based on spring 1994 tests. The results were:

Adjusted test mortality = 15.04%
 Station Average* = 15.04%

* All units are identical at Feeder Dam.

- The adjustment factor was calculated by dividing the RMC Glens Falls station average by the Feeder Dam station average, as follows:

<u>RMC average</u>	=	<u>34.93%</u>	=	<u>2.32</u>
Feeder average		15.04%		

- This adjustment factor (2.32) was applied to mortality rates determined for all species and size groups at Feeder Dam, to estimate the mortality of the same species and size groups at the Glens Falls Project. This is based on the conservative assumption that factors affecting survival of all species during turbine passage at both projects will be similar to the factors affecting the survival of medium to large-sized bass. This assumption is also conservative in that it does not account for the adverse test

conditions that occurred during the RMC study (peak summertime air and water temperatures), which may have affected test fish survival. If the RMC rates are overestimated due to adverse test conditions, the adjustment factor would also be overestimated.

3.5 Cost Benefit Analysis for Installation of Fish Protection Structures

As previously described, Finch, Pruyn retained Acres to develop conceptual designs and cost estimates for fish protection structures at the Glens Falls Project, based on the current agency criteria for such structures in New York State (one-inch spaced angled trashracks). The benefits of installing these structures at Glens Falls were estimated by:

- (1) Screening the database of entrained fish to remove those fish with maximum measured body widths of greater than one inch (25 mm) which would represent those fish "screened" by one-inch spaced trashracks, and thus would not enter the station;
- (2) Applying the fish cost database (value of fish based on the AFS 1992 publication) to the estimate of those remaining fish that are entrained and are killed during turbine passage; and
- (3) Comparing the difference in value of fish entrained and killed under existing conditions (1-5/8-inch racks) and fish entrained and killed with one-inch racks, to the cost of the installation and maintenance of a fish protection structure.

This was to be an "order-of-magnitude" cost comparison unless the costs were close enough to warrant a more detailed economic analysis. The results indicated that a detailed benefit/cost analysis was not required (see Section 4.5).

This may be considered a conservative analysis in that the exclusionary effect of the one-inch racks was assumed to be limited to the physical exclusion of fish that could not pass through a one-inch space. Similarly, the database screening for the 1-5/8-inch spacing at Glens Falls also assumed that only fish wider than 1-5/8 inches would be excluded. Any behavioral effects of either rack spacing could not be quantified. For this project, however, the analysis of relative differences in fish entrainment between 1-5/8-inch and 1-inch spacing provides the best available quantitative assessment of the benefits of 1-inch racks.

**TABLE 3-1
SCHEDULE OF FEEDER DAM
SAMPLING EVENTS**

MONTH	WEEK	DURATION SAMPLING (hrs)	SAMPLING SCHEDULE
October 1993 Preliminary Entrainment Sampling and Proof-of- Concept	1	48	X
	2	48	
	3	48	X
	4	48	
November 1993	5	48	X
	6	48	
	7	48	X
	8	48	
December 1993	9	24	X
	10	24	X
	11	24	
	12	24	X
	13	24	
January 1994	14	24	
	15	24	X
	16	24	
	17	24	S
February 1994	18	24	
	19	24	S
	20	24	
	21	24	X
March 1994	22	48	
	23	48	X
	24	48	
	25	48	X
	26	48	
April 1994	27	48	X
	28	48	
	29	48	
	30	48	X
May 1994	31	48	
	32	48	X
	33	48	X
	34	48	X
June 1994	35	48	
	36	48	X
	37	48	X
	38	48	X
	39	48	

TABLE 3-1
SCHEDULE OF FEEDER DAM
SAMPLING EVENTS

MONTH	WEEK	DURATION SAMPLING (hrs)	SAMPLING SCHEDULE
July 1994	40	24	
	41	24	X
	42	24	
	43	24	X
August 1994	44	24	
	45	24	X
	46	24	
	47	24	X
	48	24	
September 1994	49	48	X
	50	48	
	51	48	X
	52	48	
October 1994	53	48	X
	54	48	
	55	48	X
	56	48	
November 1994	57	48	X

X = Sampled dates

S = Data from sample week #10 substituted

TABLE 3-2
CONDITION CODES AND DESCRIPTIONS
USED TO ASSESS FISH STATUS DURING ENTRAINMENT SAMPLING
AT FEEDER DAM

CONDITION CODE	CONDITION DESCRIPTION
00	Dead, no external physical damage apparent
01	Dead, fish intact, external physical damage appears likely to be related to turbine passage
02	Dead, fish not intact, all portions recovered, damage appears likely to be related by turbine passage
03	Dead, fish not intact, all portions not recovered, damage appears likely to be related to turbine passage
04	Dead, fish intact, external physical damage does not appear to be related to turbine damage
05	Dead, decomposing fish, external damage and/or decomposition does not appear to be related to turbine damage
06	Dead, fish not intact, all portions recovered, damage does not appear to be related to turbine passage
07	Dead, not intact, all portions not recovered, damaged does not appear to be related to turbine passage
08	Dead, tagging scar present
09	Dead, tag recovery
10	Live, no external physical damage apparent
11	Live, with external physical damage apparently related to turbine passage
12	Live, with external physical damage not apparently related to turbine passage
13	Live, fish not intact, all portions recovered, damage appears likely to be related to turbine passage
15	Live, fish tagged and released into tailrace
16	Live, tag recovery
17	Live, tagging scar noted

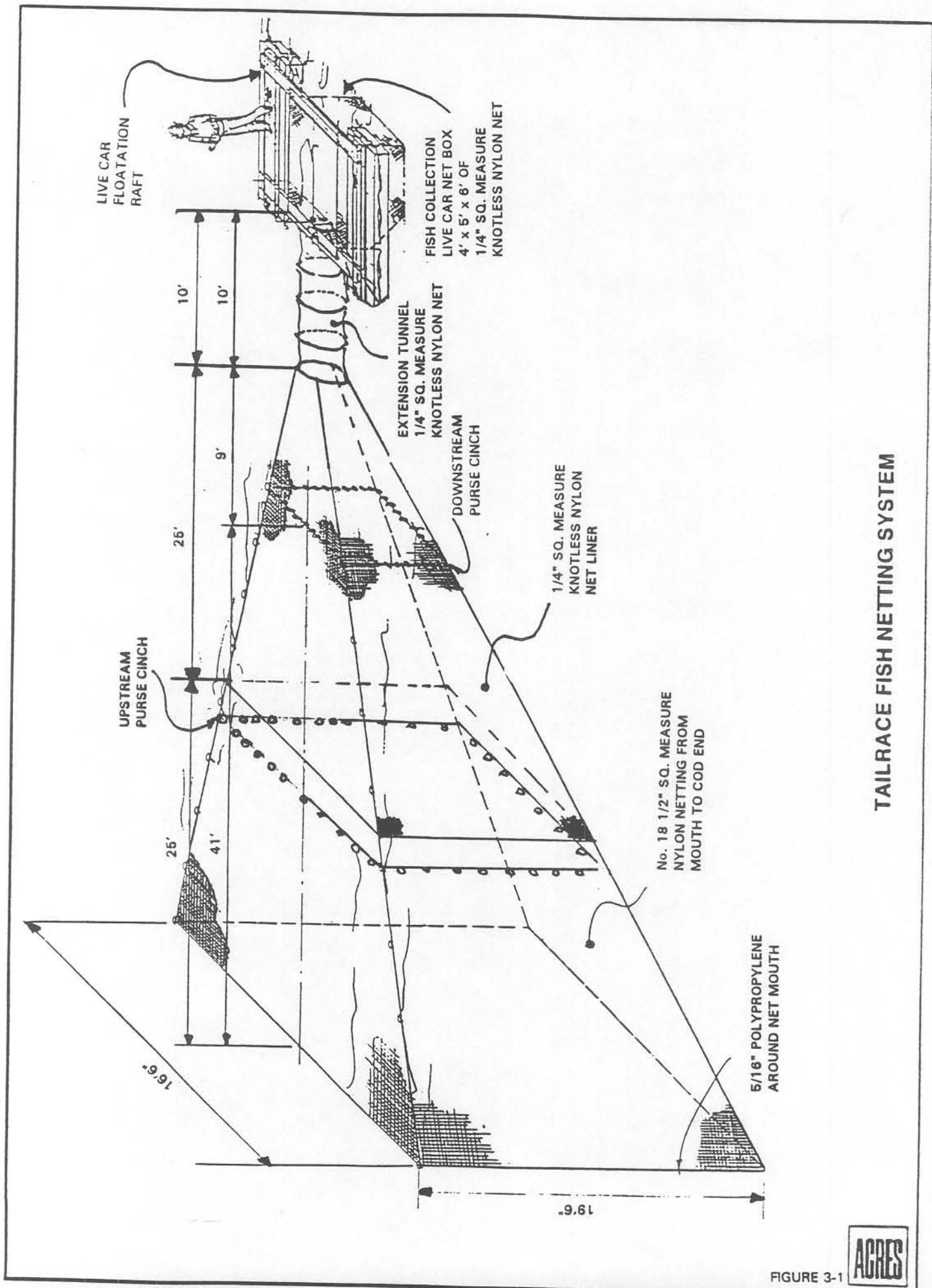
TABLE 3-3
LIST OF EFFICIENCY AND MORTALITY TEST
FISH SPECIES UTILIZED
DURING THE FEEDER DAM FISH
ENTRAINMENT STUDY

FISH SPECIES	AVERAGE LENGTH (mm)	SIZE RANGE (mm)
Golden Shiner	88	51-175
Bluegill S.F. (small)	91.6	26-175
Bluegill S.F. (large)	128.6	76-200
Largemouth Bass (small)	87.7	51-175
Largemouth Bass (medium)	190.0	126-325
Largemouth Bass (large)	292.1	226-350
Brown Trout (small)	87.1	51-125
Brown Trout (large)	205.5	151-250
Walleye (small)	91.3	51-150
Walleye (large)	156.7	101-250
Crappie	96.6	51-150
Rainbow Trout (small)	147.7	126-175
Rainbow Trout (large)	251.4	226-300
Yellow Perch (small)	94.3	76-125

TABLE 3-4
FORMULAS USED IN ENTRAINMENT EXTRAPOLATION ESTIMATES¹

NUMBER	FORMULA	COMMENT
1	$\text{Turbine Discharge (cfs)} \times \text{Sample Duration (seconds)} = \text{Sample Volume (ft}^3\text{)}$	Estimate of volume of water sampled during a sample event
2	$\text{No. of Fish/Volume of Water Sampled (cubic feet)} = \text{Fish/ft}^3$	Estimates a density of fish per ft ³ during a sample event
3	$\text{Volume (ft}^3\text{) Unit 1} + \text{Volume (ft}^3\text{) Unit 2} + \text{Volume (ft}^3\text{) Unit 3} = \text{Total Volume (ft}^3\text{)}$	Estimates the total volume passed by Units 1, 2 and 3 for a 24-hour period
4	$\text{Fish/ft}^3 \text{ (Formula 2)} \times \text{Volume (ft}^3\text{) (Formula 3)} = \text{No. Fish}$	Estimates number of fish entrained through Units 1, 2 and 3 for a 24-hour period
5	$\text{Volume (ft}^3\text{) Unit 4} + \text{Volume (ft}^3\text{) Unit 5} = \text{Total Volume (ft}^3\text{)}$	Estimates the total volume passed by Units 4 and 5 for a 24-hour period
6	$\text{Fish/ft}^3 \text{ (Formula 2)} \times \text{Volume (ft}^3\text{) (Formula 5)} = \text{No. Fish}$	Estimates number of fish entrained through Units 4 and 5 for a 24-hour period
7	$\text{No. Fish Units 1, 2 and 3 (Formula 4)} + \text{No. Fish Units 4 and 5 (Formula 6)} = \text{No. Fish}$	Estimates number of fish entrained through entire station for a 24-hour period
8	$\text{Sample Date 2} - \text{Sample Date 1} \div 2 \text{ through Sample Date 3} - \text{Sample Date 2} \div 2 = \text{No. of Days}$	Estimates number of days represented by sample period (generally 7 days prior and 7 days after the sample event)
9	$\text{No. Days (Formula 8)} \times \text{No. Fish (Formula 7)} = \text{No. Fish for Sample period}$	Estimates total station entrainment for the sample period (approximately 14 days)
10	$\text{Sum of No. Fish for all Sample Periods} = \text{Annual entrainment}$	Estimates total station entrainment for one year

¹See Figure 3-3 for Flow Diagram



TAILRACE FISH NETTING SYSTEM

JOB NUMBER **P2519.06**
 FILE NUMBER
 SHEET **1** OF **1**
 BY **JPS** DATE **2-29-23**
 APP DATE

Calculations
 SUBJECT: **FEEDER DAM**
PISH INJECTION FRAME - ONE REQ.



NOTES

1. USE PVC SCH 80 4" ϕ PIPE & FITTINGS
2. APPROX. WT. OF FRAME = 155 #
3. USE THREADED FITTINGS TO ALLOW FOR FIELD ADJUSTMENTS

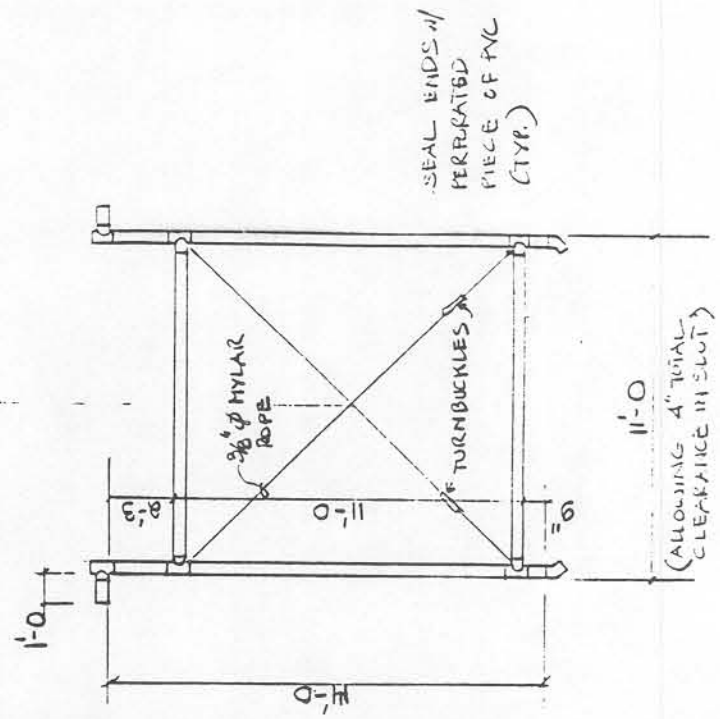
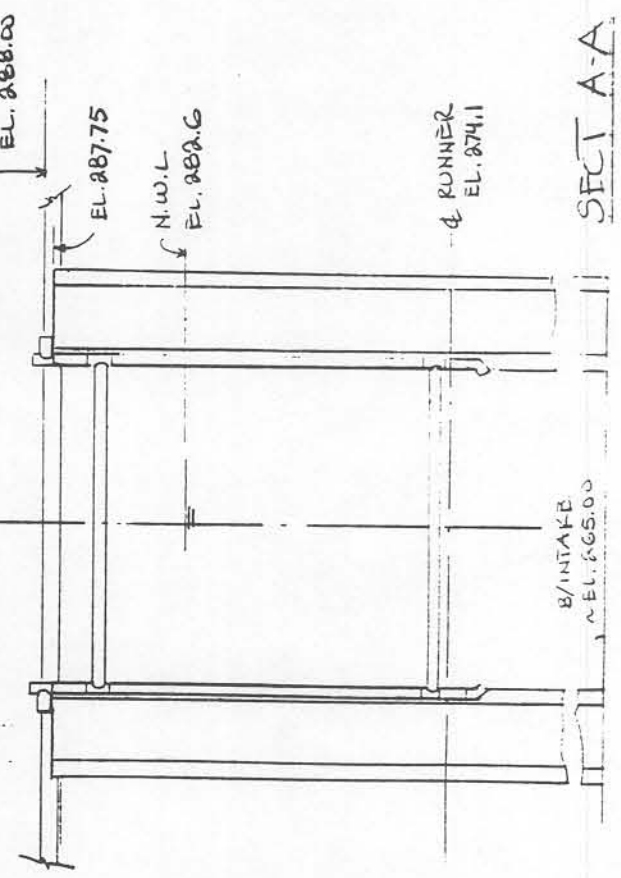
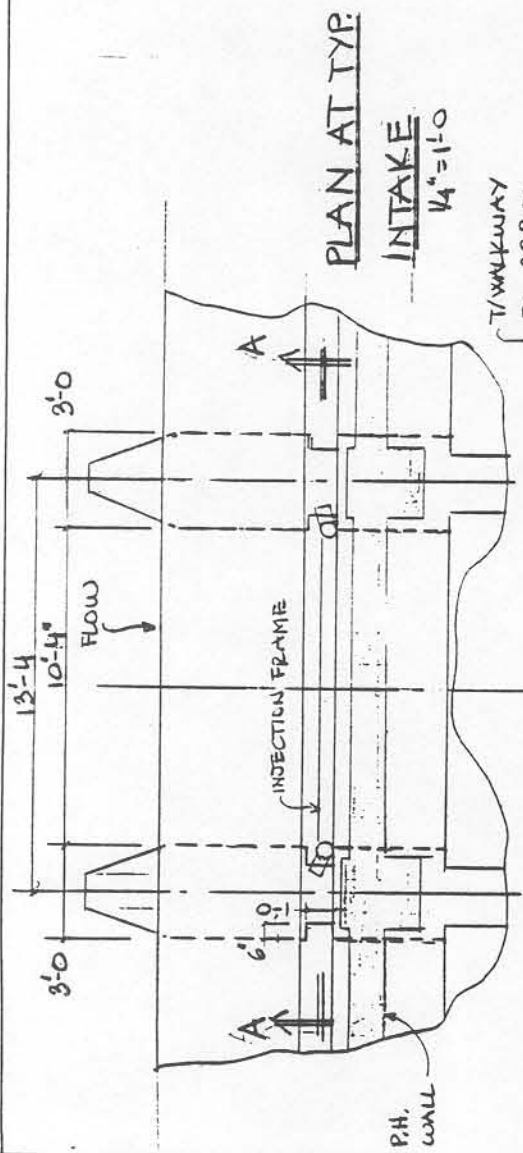


FIGURE 3-2

Turbine Units 1, 2 & 3

Number of Fish
Per Sample +
Units 1 or 3

Fish / Volume

Volume of Water
Per Sample
Units 1 or 3

• Formula 2

Total Turbine Group
Volume of Water
(24 hours)
Units 1, 2 & 3

• Formula 3

Number of Fish
(24 hours)
Units 1, 2 & 3

• Formula 4

Turbine Units 4 & 5

Number of Fish
Unit 5 +

Fish / Volume

• Formula 2

Volume of Water
Unit 5

• Formula 1

Total Turbine Group
Volume
Units 4 & 5

• Formula 5

Number of Fish
Units 4 & 5

• Formula 6

Number of Days
Represented by
Sample Period

• Formula 8

Number of Fish
Entrained for Entire
Station (Daily)

• Formula 7

Estimate of Total
Entrainment for
the Sample Period
(Approx. 2 weeks)

• Formula 9

Annual Estimate
of Total Station
Entrainment

• Formula 10

+ Adjusted by net efficiency

• See Table 3-4 for formulas

Feeder Dam Fish Entrainment

Flow Diagram

Estimates of Total Annual Fish Entrainment

Figure 3-3



4 RESULTS

This section describes the results of the entrainment sampling, net efficiency, and mortality testing at Feeder Dam, and the entrainment mortality extrapolations for the Glens Falls Project. Sections 4.1 through 4.3 describe the Feeder Dam field study results, while Sections 4.4 and 4.5 describe the results as applied to the Glens Falls Project.

4.1 Entrainment Sampling Results

Entrainment sampling was initiated at Feeder Dam in early October 1993. During the month of October several activities were occurring simultaneously with the initial sampling. These included:

- Completion of access decks and facilities construction;
- Making final adjustments and modifications to the sampling gear to improve efficiency or facilitate sampling;
- Correction of net-tearing and abrasion problems by installation of canvas protectors on all nets;
- Mobilization for initial net efficiency and turbine mortality tests; and
- Conducting initial net efficiency and mortality tests.

Because of these several ongoing activities and recurring net-tearing problems in the early samples, several of the October samples were not successfully completed and were not considered to be representative of entrainment at the project. Thus, none of the October samples were to be used in the entrainment analysis, and the official start of sampling was in mid-November 1993. Sampling continued into the first week of November 1994. The October 1993 data, however, is included as Appendix B, for general informational purposes.

Raw Catch Results

Using the Feeder Dam database screened to remove fish with widths greater than 1½ inches, a total of 2,216 fish representing 29 species was collected during this one-year sampling program (Table 4-1). The catch was dominated by the centrarchids (bass and sunfish), bullheads/catfishes, yellow perch, and minnows. This is typical for a warmwater-/coolwater fish community in upstate New York, and is similar to the species composition determined in 1993 studies in the Glens Falls impoundment (Acres, 1993). Small numbers of trout were collected, although some of these fish may have been recaptures of unmarked test fish that escaped from the holding pens (this was documented on a few occasions). Two adult American eel were collected at Feeder Dam, but after screening the Feeder Dam database, both specimens were not included in the Glens Falls database, since their widths exceeded 1½ inches. This species is catadromous (lives in freshwater and

spawns in the ocean), although it is not known if juvenile eels (elvers) are able to pass upstream through the several downstream Hudson River dams, none of which are equipped with fish passage facilities. No threatened or endangered species were collected during the program.

A summary of the raw entrainment catch by sample event is included in Appendix C. This summary is reported by date and sample number, and includes which units were sampled and the duration of each sample. Table 4-2 provides a monthly summary of the raw catch. Based on these data, the highest catches occurred during the month of June, while the lowest catches occurred during the winter months of November, December, and January. The highest catches generally occurred during the "warmer" months of the year, April through August.

Table 4-3 lists the raw catch by unit at Feeder Dam, after screening the data for 1½ inches. These data indicate that more fish were collected in Unit 5, followed by Unit 3 and Unit 1. This, however, is not necessarily a reflection of where fish pass through the powerhouse, but the sample frequency for each unit. For example, Unit 5 was sampled on every sample event (except when the Unit 5 deck was flooded), while Units 1 and 3 were sampled on an alternating basis. Unit 1 was sampled the least, however, because the unit could not be sampled during the winter months. A comparison of the overall catch per hour for each unit indicated a similar catch per effort. Using data from Table 4-3, the overall catch per hour was as follows:

- Unit 1 = 1.29 fish/hr;
- Unit 3 = 1.06 fish/hr; and
- Unit 5 = 1.01 fish/hr.

Length frequency distributions for eleven most common species that comprised about 85 percent of the total catch are reported in Table 4-4 (for collections not screened for widths). These data indicate that a wide range of length and age groups, from juveniles through adults, were collected for most species, although few large fish were taken. For these eleven species combined, fish less than 100 mm (4 inches) comprised 40.8 percent of the catch, fish 100 to 200 mm (4 to 8 inches) comprised 45.5 percent, fish 200 to 300 mm (8 to 12 inches) comprised 12.4 percent, and fish greater than 300 mm comprised 1.3 percent of the catch.

Net Intrusion from Tailrace Population

During spring 1994 sampling, as catches of centrarchid species increased, field personnel began to suspect that fish residing in the tailrace were entering the entrainment nets. This was based on observations of schools of large rock bass and redbreast sunfish that appeared in the tailrace beginning in May, and the subsequent increase in the catch of

similar-sized individuals of these species. Tailrace fishes could enter the draft tubes when the units were shut down immediately prior to setting the nets (it usually required one to two hours to set both nets on a sampled unit). Any tailrace fish entering the draft tubes would be trapped once the net frames were lowered into place, and would likely enter the nets when the sampled unit was restarted. Net intrusion in this manner would result in an overestimation of entrainment, perhaps significantly.

In an effort to test whether net intrusion was occurring, and to determine the extent of net intrusion, Acres initiated a tagging program in May 1994. All live taggable-sized (≥ 150 mm) species collected in the nets, and to be returned to the tailrace, were tagged with a numbered Floy spaghetti tag prior to release. The subsequent recapture of these tagged fish would verify that net intrusion was occurring.

This program verified that net intrusion was occurring. A total of 10 species and 595 individual fish was tagged (Table 4-5), and 95 recaptures (16.0 percent) were made for four species (Table 4-6). Net intrusion appeared to be somewhat seasonal in nature, with the highest catches of the most common species (rock bass and redbreast sunfish) occurring in the spring and fall. The overall intrusion rate for the four recaptured species ranged from 3.0 to 17.1 percent, although on individual collection dates up to 100 percent of a particular species collected were tagged fish from the tailrace. These data indicate that net intrusion is a significant factor in overestimating turbine entrainment.

The precise portion of the entrainment catch attributed to net intrusion, however, cannot be estimated using this tagging program, based on the following considerations:

- Not all size groups were tagged (generally only fish ≥ 150 mm), thus intrusion of smaller-sized fish cannot be estimated;
- Since not all fish present in the tailrace at any one time are tagged, untagged tailrace fish captured in the net cannot be differentiated from entrained fish; and
- A reliable population estimate of fish in the tailrace cannot be made because the tailrace is not a "closed system" (thus violating one of the assumptions of a mark recapture estimate), preventing any comparison of the number of tagged fish captured in the entrainment nets to the estimated number of fish in the tailrace.

We concluded that the best use of the tagging data was to reduce the daily entrainment catch and later estimate, for the species and size groups tagged, by the number of these specific groups that were recaptured in the nets (i.e., remove any recaptured fish from the database). Thus, with this conservative treatment of the tagging results, entrainment through the station will likely be overestimated and should be considered conservatively high.

4.2 Efficiency Test Results

Efficiency tests were conducted during the fall of 1993 (October 20 through December 2, 1993), and in the spring of 1994 (May 11 through June 22, 1994). As described previously, the fall 1993 efficiency tests were conducted during the period when net damage was occurring, subsequent net repairs and modifications were in progress, and some of the sampling techniques were still being developed. As a result, the net efficiencies appeared to be highly variable (Table 4-7), and in general, these test results did not meet agency approval. Both the USFWS and NYSDEC requested that efficiency tests be repeated in the spring of 1994.

The results of the spring 1994 tests are summarized in Table 4-8. In general, these results indicated consistently higher efficiencies than occurred during the fall 1993 tests, although individual test groups occasionally exhibited relatively low efficiencies. If the tests for each species and size category are grouped, however, the overall category efficiencies meet the minimum agency criteria of 70 percent, except for two species. Small brown trout exhibited an efficiency of 40.5 percent, and golden shiner had an efficiency of 63.6 percent. It is believed that these relatively low efficiencies were a function of fish size, in that these smaller size groups were able to pass through the 1/2-inch mesh of the tailrace nets. In contrast, efficiencies of small bass and bluegill were relatively high, but these species are less fusiform in body shape than small trout and golden shiner, and could not easily pass through the 1/2-inch mesh. Small brown trout, due to their strong swimming ability, may also avoid capture in the net by maintaining themselves in the draft tube discharge and escaping when the nets were retrieved.

The spring 1994 efficiency results were considered acceptable by the USFWS and the NYSDEC, and the agreed-upon species groupings for efficiencies are presented in Table 4-9. These were the efficiencies used in the entrainment extrapolations.

4.3 Mortality Test Results

Mortality tests were conducted at the same time as the efficiency tests in the fall, 1993 and spring 1994. The fall 1993 tests experienced the difficulties as previously described for the efficiency tests, and the agencies recommended that mortality tests be repeated in the spring 1994. The results of the spring, 1994 tests are presented in Table 4-10, and will form the basis for mortality estimates. In general, the spring 1994 tests were successfully completed, although some tests experienced high mortality of control fish. This high control fish mortality is believed to be related to the manner in which test fish are recovered. Most fish must be removed from the body of the net after net retrieval, since few fish accumulate in the live cars, due to low tailrace velocities, and the ability of the test fish to remain free swimming in the body of the net. Fish removed from the net

body after the net is landed on the deck experience significantly more handling, and are "out of the water" for several minutes.

Because of the concern that high control fish mortality may mask the effects of turbine passage, the USFWS and NYSDEC recommended that the mortality tests results be screened, and that only those tests be used where control fish survival was equal to or greater than 85 percent. The results of this screening are presented in Table 4-11. Using this criteria, a total of 22 tests for fish recovered immediately after net retrieval, 12 tests for fish held 24 hours after net retrieval, and 5 tests for fish held 48 hours after net retrieval would be considered "acceptable".

The applicant is proposing that the "24-hour tests" be used as the basis for mortality calculations at Feeder Dam, since these results reflect any latent mortality occurring up to 24 hours after test fish were recaptured. Using these tests, however, results in the elimination of all tests for the small and large strong-swimming categories (because of high control fish mortality). Thus, substitute mortality rates had to be developed for these groups. Based on general body shape, the small and medium-sized largemouth bass mortality rates have been substituted for the small and medium-sized strong swimmer rates. The 24-hour mortality rate for the largest strong swimmer size group has been calculated by determining the ratio of the immediate to 24-hour mortality rates for medium and large-sized bass, and applying this ratio to the immediate rate determined for large trout. Table 4-12 summarizes the mortality rates used in the mortality estimates, and Table 4-13 presents the proposed species groupings for mortality calculations.

In response to comments received from the USFWS and NYSDEC, Acres also calculated a range of alternative mortality rates that would illustrate the maximum range of mortality possible (from lowest to highest), based on available data.

For the minimum estimated mortality category, the following rates were determined:

- (1) The percentage of naturally-entrained dead fish (no test fish) recovered from the live cars, that also had evidence of turbine blade strike (cuts, abrasions, descaling);
- (2) Rates adjusted for control survival, calculated from spring 1994 24-hour tests, using tests where control survival was at least 85 percent and the assumption that all non-recovered fish are alive; and
- (3) Adjusted rates calculated from spring 1994 immediate test results, using tests where control survival was at least 85 percent. If any adjusted survivals exceeded 100 percent, they would be assumed to be 100 percent.

For the maximum estimated mortality category, the following rates were determined:

- (1) The percentage of naturally entrained, dead fish (from all causes) recovered from the live cars;
- (2) Adjusted rates calculated from spring 1994 24-hour tests, using tests where control survival was at least 85 percent and the assumption that all non-recovered fish are dead; and
- (3) Rates calculated from spring 1994 immediate test results, only using tests where control survival was at least 85 percent, but not adjusted for control survival.

Table 4-14 summarizes the full range of mortality rates calculated for Feeder Dam, although the rates considered to have the best scientific justification are those identified on Table 4-14 as "Acres Best Estimate." Mortality estimates based on these rates and on the adjustment factor for the Glens Falls Project (2.32), are described in Section 4.4.

4.4 Entrainment and Mortality Estimates at the Glens Falls Project

Based on data collected at Feeder Dam, an estimated 38,746 fish were entrained at the Glens Falls Project during the one-year study period. On a monthly and seasonal basis, entrainment was highest during the spring and summer period, and lowest during the winter (Table 4-15). Appendix D contains the detailed entrainment extrapolations for all species, size groups, and sample periods. Based on the "best-estimate" mortality rates determined for the Feeder Dam study (see Table 4-12), adjusted by the Glens Falls adjustment factor (2.32), an estimated 6,807 fish were killed during passage during this one-year period. Table 4-16 summarizes the numbers of fishes entrained and killed, by species, while Appendix E presents a detailed breakdown of entrainment and mortality by species and size group. As with the raw catch, entrained species were dominated by the centrarchids, bullheads, yellow perch, and cyprinids. Overall, an estimated 17.6 percent of those fish entrained were killed during powerhouse passage, using the "best-estimate" mortality rates.

For comparison, Table 4-17 summarizes the potential range of mortality at the project using the range of rates listed in Table 4-14 (assuming the existing project configuration). The "best-estimate" was that 6,807 would be killed during passage over the 12-month study period. The potential range of mortality, however, is from 3,085 fish to 19,343 fish per year. The "worst-case" estimate based on the calculation method suggested by the USFWS (no adjustment for control fish mortality) was an annual mortality of 8,312 fish, only about 1,500 fish higher than the "best estimate."

4.5 Results of Cost Benefit Analysis for the Glens Falls Project

Table 4-17 presents the overall value of fish killed at the project for the potential range of mortality rates, and Appendix E presents a detailed breakdown of fish losses and costs by species and size group using the "best estimate" mortality rate. From Table 4-17, the "best estimate" value of current fish losses at the Glens Falls Project (with the existing trashracks) is \$9,402. The potential range of fish losses is from \$3,307 to \$15,936 per year.

Table 4-18 presents the results of the same analysis, but after the database had been screened to remove all fishes with a body width of greater than one inch (25 mm). This table represents those fishes that would still be entrained by the project, with one-inch spaced trashracks installed. It is assumed that fish greater than one-inch in width would not enter the station and would not be killed. Thus, the benefit of the one-inch spaced trashracks would be the differences in fish value between Tables 4-17 and 4-18 (the value of fish "saved"). Table 4-19 summarizes these benefits.

This analysis indicates that the benefit of installing fish protective structures with one-inch-spaced racks ranges from \$1,150 to \$3,675 per year. The "best estimate" benefit would be \$3,675 per year. In comparison, the cost of alternative fish protection structures (see Appendix A) would be as follows:

	Construction Cost (1996)	Annual Energy Loss
Alternative A	\$2,420,000	\$54,100
Alternative B	\$1,959,000	\$68,200
Alternative B1	\$1,202,000	\$50,900
Alternative B2	\$1,500,000	\$27,000
Alternative C	\$1,702,000	\$50,900

Based on these estimates, the benefits of providing structures would be greatly outweighed by the cost of construction and operation of the structures. The maximum benefit of \$3,675 per year, carried over 40 years of a license term would be \$147,000 (without escalation). The least-expensive structural alternative would cost more than eight times the long-term benefit, not counting the annual energy losses and increased maintenance costs related to more frequent raking.

When considering the annual energy losses and an assumed \$10,000 annual maintenance cost increase, the minimum 40-year project cost for structural fish protection will be 24 times the estimated long-term cost of fish mortality.

Table 4-1: Summary of total raw catch for Glens Falls.
(Feeder Dam data screened for 41 mm width fish)

Species	Count	Percent
-----	-----	-----
Rainbow trout	11	0.48
Brown trout	12	0.52
Brook trout	1	0.04
Rainbow smelt	36	1.57
Pikes	2	0.09
Northern pike	1	0.04
Chain pickerel	10	0.43
Carps and Minnows	27	1.17
Common carp	2	0.09
Golden shiner	131	5.70
Emerald shiner	17	0.74
Spottail shiner	4	0.17
Bluntnose minnow	2	0.09
Blacknose dace	1	0.04
Fallfish	16	0.70
Shiners	31	1.35
Dace	1	0.04
Minnows	2	0.09
Northern hogsucker	1	0.04
Bullheads/Catfishes	45	1.96
Yellow bullhead	182	7.91
Brown bullhead	48	2.09
Channel catfish	6	0.26
Sunfishes	23	1.00
Rock bass	392	17.04
Redbreast sunfish	381	16.57
Pumpkinseed	224	9.74
Bluegill	21	0.91
Smallmouth bass	52	2.26
Largemouth bass	65	2.83
White crappie	1	0.04
Black crappie	11	0.48
Sunfish	203	8.83
Darters	1	0.04
Tessellated darter	36	1.57
Yellow perch	176	7.65
Logperch	14	0.61
Walleye	6	0.26
Unknown fish remains	21	0.91

=====

Total count 2216

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Table 4-2: Summary of raw catch by month for Glens Falls.
(Feeder Dam data screened for 41 mm width fish)

Page: 1 of 13

Sample Year: 93 Sample Month: 11

Number of netting samples: 4

Species -----	Count -----
Brown trout	1
Brook trout	1
Rainbow smelt	2
Pikes	1
Chain pickerel	2
Carps and Minnows	2
Golden shiner	10
Emerald shiner	5
Bluntnose minnow	2
Yellow bullhead	6
Sunfishes	1
Rock bass	3
Pumpkinseed	10
Largemouth bass	2
Black crappie	4
Darters	1
Yellow perch	6
Walleye	1
	=====
Total Monthly Count	60

Table 4-2: Summary of raw catch by month for Glens Falls.
(Feeder Dam data screened for 41 mm width fish)

Page: 2 of 13

Sample Year: 93 Sample Month: 12

Number of netting samples: 4

Species -----	Count -----
Rainbow trout	2
Chain pickerel	2
Carps and Minnows	1
Golden shiner	3
Emerald shiner	3
Bullheads/Catfishes	1
Yellow bullhead	4
Rock bass	1
Redbreast sunfish	2
Pumpkinseed	7
Black crappie	2
Tessellated darter	1
Yellow perch	2
Walleye	1
Unknown fish remains	5
	=====
Total Monthly Count	37

Table 4-2: Summary of raw catch by month for Glens Falls.
(Feeder Dam data screened for 41 mm width fish)

Page: 3 of 13

Sample Year: 94 Sample Month: 1

Number of netting samples: 4

Species	Count
-----	-----
Rainbow trout	2
Chain pickerel	1
Carps and Minnows	1
Golden shiner	3
Emerald shiner	3
Yellow bullhead	5
Rock bass	1
Redbreast sunfish	2
Pumpkinseed	7
Tessellated darter	1
Yellow perch	1
Walleye	1
Unknown fish remains	4
	=====
Total Monthly Count	32

Table 4-2: Summary of raw catch by month for Glens Falls.
(Feeder Dam data screened for 41 mm width fish)

Page: 4 of 13

Sample Year: 94 Sample Month: 2

Number of netting samples: 4

Species	Count
-----	-----
Rainbow trout	2
Chain pickerel	1
Carps and Minnows	1
Golden shiner	5
Emerald shiner	4
Shiners	1
Yellow bullhead	23
Sunfishes	3
Rock bass	1
Redbreast sunfish	5
Pumpkinseed	8
Bluegill	1
Largemouth bass	1
Tessellated darter	2
Yellow perch	3
Walleye	1
Unknown fish remains	5
	=====
Total Monthly Count	67

Table 4-2: Summary of raw catch by month for Glens Falls.
(Feeder Dam data screened for 41 mm width fish)

Page: 5 of 13

Sample Year: 94 Sample Month: 3

Number of netting samples: 4

Species -----	Count -----
Rainbow smelt	1
Chain pickerel	1
Carps and Minnows	3
Common carp	1
Golden shiner	18
Shiners	9
Northern hogsucker	1
Bullheads/Catfishes	19
Yellow bullhead	44
Brown bullhead	1
Sunfishes	7
Redbreast sunfish	6
Largemouth bass	1
Sunfish	11
Tessellated darter	5
Yellow perch	3
Unknown fish remains	1
	=====
Total Monthly Count	132

Table 4-2: Summary of raw catch by month for Glens Falls.
(Feeder Dam data screened for 41 mm width fish)

Page: 6 of 13

Sample Year: 94 Sample Month: 4

Number of netting samples: 5

Species	Count
-----	-----
Rainbow smelt	15
Northern pike	1
Chain pickerel	1
Carps and Minnows	5
Golden shiner	4
Shiners	1
Minnows	2
Bullheads/Catfishes	22
Yellow bullhead	26
Brown bullhead	9
Sunfishes	9
Rock bass	4
Redbreast sunfish	3
Pumpkinseed	8
Largemouth bass	10
Black crappie	1
Sunfish	103
Tessellated darter	10
Yellow perch	14
Unknown fish remains	2
	=====
Total Monthly Count	250

Table 4-2: Summary of raw catch by month for Glens Falls.
(Feeder Dam data screened for 41 mm width fish)

Page: 7 of 13

Sample Year: 94 Sample Month: 5

Number of netting samples: 7

Species	Count
-----	-----
Rainbow trout	5
Brown trout	5
Rainbow smelt	17
Pikes	1
Golden shiner	14
Blacknose dace	1
Fallfish	1
Shiners	10
Dace	1
Bullheads/Catfishes	1
Yellow bullhead	8
Brown bullhead	23
Rock bass	151
Redbreast sunfish	47
Pumpkinseed	30
Bluegill	8
Smallmouth bass	3
Largemouth bass	13
Black crappie	1
Sunfish	69
Tessellated darter	17
Yellow perch	89
Logperch	13
Walleye	2
	=====
Total Monthly Count	530

Table 4-2: Summary of raw catch by month for Glens Falls.
(Feeder Dam data screened for 41 mm width fish)

Page: 8 of 13

Sample Year: 94 Sample Month: 6

Number of netting samples: 7

Species	Count
-----	-----
Brown trout	6
Rainbow smelt	1
Chain pickerel	1
Carps and Minnows	5
Golden shiner	59
Emerald shiner	1
Spottail shiner	3
Fallfish	15
Shiners	5
Bullheads/Catfishes	2
Yellow bullhead	3
Brown bullhead	13
Rock bass	134
Redbreast sunfish	169
Pumpkinseed	68
Bluegill	3
Smallmouth bass	33
Largemouth bass	3
Sunfish	15
Yellow perch	26
Logperch	1
Unknown fish remains	4
	=====
Total Monthly Count	570

Table 4-2: Summary of raw catch by month for Glens Falls.
 (Feeder Dam data screened for 41 mm width fish)

Page: 9 of 13

Sample Year: 94 Sample Month: 7

Number of netting samples: 4

Species	Count
-----	-----
Golden shiner	9
Emerald shiner	1
Shiners	1
Brown bullhead	2
Rock bass	24
Redbreast sunfish	22
Pumpkinseed	20
Bluegill	5
Smallmouth bass	7
Largemouth bass	5
Yellow perch	3
	=====
Total Monthly Count	99

Table 4-2: Summary of raw catch by month for Glens Falls.
(Feeder Dam data screened for 41 mm width fish)

Page: 10 of 13

Sample Year: 94 Sample Month: 8

Number of netting samples: 4

Species	Count
-----	-----
Carps and Minnows	4
Common carp	1
Shiners	2
Yellow bullhead	3
Rock bass	17
Redbreast sunfish	52
Pumpkinseed	9
Bluegill	1
Smallmouth bass	6
Largemouth bass	15
Sunfish	2
Yellow perch	1
	=====
Total Monthly Count	113

Table 4-2: Summary of raw catch by month for Glens Falls.
 (Feeder Dam data screened for 41 mm width fish)

Page: 11 of 13

Sample Year: 94 Sample Month: 9

Number of netting samples: 4

Species	Count
-----	-----
Carps and Minnows	4
Golden shiner	3
Yellow bullhead	55
Channel catfish	6
Rock bass	37
Redbreast sunfish	38
Pumpkinseed	7
Bluegill	3
Smallmouth bass	3
Largemouth bass	1
Sunfish	3
Yellow perch	1
	=====
Total Monthly Count	161

Table 4-2: Summary of raw catch by month for Glens Falls.
(Feeder Dam data screened for 41 mm width fish)

Page: 12 of 13

Sample Year: 94 Sample Month: 10

Number of netting samples: 4

Species -----	Count -----
Chain pickerel	1
Carps and Minnows	1
Golden shiner	2
Spottail shiner	1
Shiners	2
Yellow bullhead	5
Sunfishes	3
Rock bass	17
Redbreast sunfish	28
Pumpkinseed	47
Largemouth bass	11
White crappie	1
Black crappie	1
Yellow perch	21
	=====
Total Monthly Count	141

Table 4-2: Summary of raw catch by month for Glens Falls.
(Feeder Dam data screened for 41 mm width fish)

Page: 13 of 13

Sample Year: 94 Sample Month: 11

Number of netting samples: 2

Species	Count
-----	-----
Golden shiner	1
Rock bass	2
Redbreast sunfish	7
Pumpkinseed	3
Largemouth bass	3
Black crappie	2
Yellow perch	6
	=====
Total Monthly Count	24

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Table 4-3: Summary of raw catch by unit at Feeder Dam.
(Feeder Dam data screened for 41 mm width fish)

Page: 1 of 3

Unit Number: 1

No. samples: 10 Total hrs.: 351.6

Species	Count
-----	-----
Brown trout	1
Pikes	1
Chain pickerel	1
Carps and Minnows	5
Golden shiner	7
Spottail shiner	1
Blacknose dace	1
Shiners	7
Bullheads/Catfishes	1
Yellow bullhead	59
Brown bullhead	17
Channel catfish	5
Sunfishes	1
Rock bass	114
Redbreast sunfish	69
Pumpkinseed	42
Bluegill	2
Smallmouth bass	22
Largemouth bass	25
Sunfish	12
Tessellated darter	3
Yellow perch	45
Logperch	10
Unknown fish remains	2

=====

Total Unit Count 453

Fish per hour: 1.29

Table 4-3: Summary of raw catch by unit at Feeder Dam.
(Feeder Dam data screened for 41 mm width fish)

Page: 2 of 3

Unit Number: 3

No. samples: 23 Total hrs.: 749.8

Species	Count
-----	-----
Rainbow trout	2
Brown trout	1
Rainbow smelt	30
Northern pike	1
Chain pickerel	5
Carps and Minnows	19
Golden shiner	45
Emerald shiner	13
Bluntnose minnow	2
Fallfish	5
Shiners	16
Minnows	2
Bullheads/Catfishes	35
Yellow bullhead	73
Brown bullhead	17
Channel catfish	1
Sunfishes	14
Rock bass	49
Redbreast sunfish	116
Pumpkinseed	60
Bluegill	14
Smallmouth bass	13
Largemouth bass	26
White crappie	1
Black crappie	2
Sunfish	166
Tessellated darter	18
Yellow perch	35
Walleye	2
Unknown fish remains	12

=====

Total Unit Count 795

Fish per hour: 1.06

Table 4-3: Summary of raw catch by unit at Feeder Dam.
(Feeder Dam data screened for 41 mm width fish)

Page: 3 of 3

Unit Number: 5

No. samples: 24 Total hrs.: 957.2

Species	Count

Rainbow trout	9
Brown trout	10
Brook trout	1
Rainbow smelt	6
Pikes	1
Chain pickerel	4
Carps and Minnows	3
Common carp	2
Golden shiner	79
Emerald shiner	4
Spottail shiner	3
Fallfish	11
Shiners	8
Dace	1
Northern hogsucker	1
Bullheads/Catfishes	9
Yellow bullhead	50
Brown bullhead	14
Sunfishes	8
Rock bass	229
Redbreast sunfish	196
Pumpkinseed	122
Bluegill	5
Smallmouth bass	17
Largemouth bass	14
Black crappie	9
Sunfish	25
Darters	1
Tessellated darter	15
Yellow perch	96
Logperch	4
Walleye	4
Unknown fish remains	7

=====

Total Unit Count 968

Fish per hour: 1.01

TABLE 4-4

Length Categories of Fish Most Commonly Captured
During 1993-1994 Fish Entrainment Sampling at Feeder Dam

Length category (mm)	Rock Bass	Red-breast sunfish	Yellow Perch	Brown bull-head	Sunfish	Large-mouth bass	Bluegill Sunfish	Small-mouth bass	Golden shiners	Yellow bull-head	Pumpkin-seed	Total	%
0-25			2		3					1		6	0.31
26-50	9	15	2	1	176	6	11			81	28	329	16.90
51-75	6	17	9	35	22	26	4	3	39	85	36	282	14.48
76-100	4	13	59	5	1	18	4	6	35	7	25	177	9.09
101-125	5	12	13	2	1	8	1	3	35	2	6	88	4.52
126-150	15	30	12			2		1	15	3	13	91	4.67
151-175	108	116	13	1		2	1	4	4	5	33	287	14.74
176-200	177	149	16	4				8		8	58	420	21.57
201-225	63	27	21	3				5	3	4	22	148	7.60
226-250	4		19					7		4	3	37	1.90
251-275	1		8	5				13		2		29	1.49
276-300	2	2	4	15		1		2		1	1	28	1.44
301-325				14		1		1				16	0.82
326-350				2		1						3	0.15
351-375				2								2	0.10
376-400				2								2	0.10
401-425												0	0.00
426-450				1				1				2	0.10
Totals	394	381	178	92	203	65	21	54	131	203	225	1,947	100.00

Table 4-5: Number of fish captured and tagged for netting samples 037 through 063, Feeder Dam Project, 1994.

Sample #	Date	Unit #	Rock Bass Captured	Rock Bass Tagged	Redbreast Sunfish Captured	Redbreast Sunfish Tagged	Pumpkinseed Captured	Pumpkinseed Tagged
037	05/27/94	5	45	39	35	22	7	4
038	05/27/94	1	27	26	3	2	2	1
039	06/06/94	3	14	12	15	15	6	4
040	06/06/94	5	46	24	30	20	26	23
041	06/06/94	3	15	12	27	21	6	5
042	06/21/94	5	23	14	29	24	2	2
043	06/21/94	5	32	22	32	23	6	4
044	06/21/94	1	18	2	23	9	5	1
045	06/21/94	1	14	0	22	5	17	2
046	07/08/94	3	1	1	0	0	1	0
047	07/08/94	5	24	7	19	8	11	3
048	07/23/94	1	3	1	2	1	1	0
049	07/23/94	3	4	1	3	1	7	7
050	08/09/94	3	0	0	1	0	1	0
051	08/09/94	5	3	1	22	20	8	7
052	08/25/94	1	6	4	22	12	2	0
053	08/25/94	5	11	3	10	6	1	0
054	09/08/94	1	2	0	6	0	1	0
055	09/08/94	5	26	16	8	2	1	0
056	09/22/94	3	21	8	8	1	1	0
057	09/22/94	5	0	0	18	5	5	0
058	10/06/94	5	13	8	21	16	33	21
059	10/06/94	3	0	0	4	0	1	0
060	10/20/94	5	9	3	5	2	8	2
061	10/20/94	1	3	1	4	0	6	0
062	11/05/94	5	1	0	4	0	3	0
063	11/05/94	1	2	0	5	0	0	0
Total			363	205	378	215	168	86

Table 4-5: Number of fish captured and tagged for netting samples 037 through 063, Feeder Dam Project, 1994 (continued).

Sample #	Date	Unit #	Smallmouth Bass		Rainbow Trout		Yellow Bullhead	
			Captured	Tagged	Captured	Tagged	Captured	Tagged
037	05/27/94	5	2	2	1	1	2	0
038	05/27/94	1	0	0	0	0	1	0
039	06/06/94	3	2	1	0	0	2	0
040	06/06/94	5	4	2	0	0	6	1
041	06/06/94	3	4	4	0	0	3	1
042	06/21/94	5	2	2	0	0	0	0
043	06/21/94	5	7	5	0	0	3	1
044	06/21/94	1	9	6	0	0	1	1
045	06/21/94	1	8	1	0	0	0	0
046	07/08/94	3	1	1	0	0	0	0
047	07/08/94	5	3	1	0	0	0	0
048	07/23/94	1	0	0	0	0	0	0
049	07/23/94	3	4	1	0	0	0	0
050	08/09/94	3	1	0	0	0	2	0
051	08/09/94	5	4	3	0	0	0	0
052	08/25/94	1	2	0	0	0	0	0
053	08/25/94	5	0	0	0	0	1	0
054	09/08/94	1	1	0	0	0	52	0
055	09/08/94	5	1	1	0	0	1	0
056	09/22/94	3	1	0	0	0	1	0
057	09/22/94	5	1	1	0	0	2	0
058	10/06/94	5	0	0	0	0	1	0
059	10/06/94	3	0	0	0	0	3	0
060	10/20/94	5	0	0	0	0	1	0
061	10/20/94	1	0	0	0	0	1	0
062	11/05/94	5	0	0	0	0	2	1
063	11/05/94	1	0	0	0	0	0	0
Total			57	31	1	1	86	5

Table 4-5: Number of fish captured and tagged for netting samples 037 through 063, Feeder Dam Project, 1994 (continued).

Sample #	Date	Unit #	Brown Bullhead		Largemouth Bass		Yellow Perch		Walleye	
			Captured	Tagged	Captured	Tagged	Captured	Tagged	Captured	Tagged
037	05/27/94	5	9	6	5	0	18	8	0	0
038	05/27/94	1	6	2	1	0	12	2	1	0
039	06/06/94	3	3	0	1	0	1	1	0	0
040	06/06/94	5	11	7	6	0	8	3	0	0
041	06/06/94	3	3	1	0	0	1	1	0	0
042	06/21/94	5	13	10	0	0	0	0	0	0
043	06/21/94	5	6	2	1	0	9	3	0	0
044	06/21/94	1	9	2	2	0	2	0	0	0
045	06/21/94	1	0	0	2	0	5	0	0	0
046	07/08/94	3	0	0	3	0	2	0	0	0
047	07/08/94	5	0	0	0	0	1	0	0	0
048	07/23/94	1	0	0	1	1	1	0	0	0
049	07/23/94	3	2	0	1	0	0	0	0	0
050	08/09/94	3	0	0	11	0	1	0	0	0
051	08/09/94	5	0	0	1	0	0	0	0	0
052	08/25/94	1	0	0	2	0	0	0	0	0
053	08/25/94	5	1	0	1	0	0	0	0	0
054	09/08/94	1	0	0	0	0	1	0	0	0
055	09/08/94	5	0	0	0	0	0	0	0	0
056	09/22/94	3	0	0	0	0	0	0	0	0
057	09/22/94	5	0	0	1	0	0	0	0	0
058	10/06/94	5	0	0	0	0	5	0	2	2
059	10/06/94	3	0	0	2	0	8	0	0	0
060	10/20/94	5	0	0	2	0	1	0	0	0
061	10/20/94	1	0	0	7	0	1	0	0	0
062	11/05/94	5	0	0	1	0	1	0	0	0
063	11/05/94	1	0	0	2	0	5	0	0	0
Total			63	30	53	1	89	18	3	2

Table 4-6: Recapture data for tagged species recaptured in tailrace entrainment netting samples 037 through 063, Feeder Dam Project, 1994.

Sample #	Date	Unit #	Rock Bass		Redbreast Sunfish	
			Captured	% Recap.	Captured	% Recap.
037	05/27/94	5	45	0.0	35	0.0
038	05/27/94	1	27	0.0	3	0.0
039	06/06/94	3	14	0.0	15	0.0
040	06/06/94	5	46	15.2	30	6.7
041	06/06/94	3	15	6.7	27	3.7
042	06/21/94	5	23	26.1	29	3.4
043	06/21/94	5	32	28.1	32	6.3
044	06/21/94	1	18	27.8	23	0.0
045	06/21/94	1	14	14.3	22	13.6
046	07/08/94	3	1	0.0	0	0.0
047	07/08/94	5	24	33.3	19	10.5
048	07/23/94	1	3	0.0	2	0.0
049	07/23/94	3	4	0.0	3	0.0
050	08/09/94	3	0	0.0	1	0.0
051	08/09/94	5	3	66.7	22	4.5
052	08/25/94	1	6	0.0	2	9.1
053	08/25/94	5	11	9.1	10	0.0
054	09/08/94	1	2	0.0	6	0.0
055	09/08/94	5	26	19.2	8	12.5
056	09/22/94	3	21	33.3	8	12.5
057	09/22/94	5	0	0.0	18	0.0
058	10/06/94	5	13	23.1	21	9.5
059	10/06/94	3	0	0.0	4	25.0
060	10/20/94	5	9	44.4	5	40.0
061	10/20/94	1	3	33.3	4	25.0
062	11/05/94	5	1	100.0	4	50.0
063	11/05/94	1	2	0.0	5	0.0
Total			363	17.1	378	6.3

Table 4-6: Recapture data for tagged species recaptured in tailrace entrainment netting samples 037 through 063, Feeder Dam Project, 1994 (continued).

Sample #	Date	Unit #	Pumpkinseed			Smallmouth Bass		
			Captured	Recaptures	% Recap.	Captured	Recaptures	% Recap.
037	05/27/94	5	7	0	0.0	2	0	0.0
038	05/27/94	1	2	0	0.0	2	0	0.0
039	06/06/94	3	6	0	0.0	2	0	0.0
040	06/06/94	5	26	0	0.0	4	0	0.0
041	06/06/94	3	6	0	0.0	4	0	0.0
042	06/21/94	5	2	0	0.0	2	0	0.0
043	06/21/94	5	6	0	0.0	7	0	0.0
044	06/21/94	1	5	0	0.0	9	0	0.0
045	06/21/94	1	17	0	0.0	8	2	25.0
046	07/08/94	3	1	0	0.0	1	0	0.0
047	07/08/94	5	11	0	0.0	3	1	33.3
048	07/23/94	1	1	0	0.0	0	0	0.0
049	07/23/94	3	7	0	0.0	4	0	0.0
050	08/09/94	3	1	1	100.0	1	0	0.0
051	08/09/94	5	8	1	12.5	4	0	0.0
052	08/25/94	1	2	1	50.0	2	1	50.0
053	08/25/94	5	1	0	0.0	0	0	0.0
054	09/08/94	1	1	0	0.0	1	0	0.0
055	09/08/94	5	1	0	0.0	1	0	0.0
056	09/22/94	3	1	0	0.0	1	0	0.0
057	09/22/94	5	5	1	20.0	1	0	0.0
058	10/06/94	5	33	1	3.0	0	0	0.0
059	10/06/94	3	1	0	0.0	0	0	0.0
060	10/20/94	5	8	0	0.0	0	0	0.0
061	10/20/94	1	6	0	0.0	0	0	0.0
062	11/05/94	5	3	0	0.0	0	0	0.0
063	11/05/94	1	0	0	0.0	0	0	0.0
Total			168	5	3.0	59	4	6.8

TABLE 4-7
RESULTS OF EFFICIENCY TESTS FOR FISH INJECTED THROUGH THE TURBINES DURING THE
FEEDER DAM ENTRAINMENT STUDY, OCTOBER 10 - DECEMBER 2, 1993¹

Date	Unit#	Species	Size (mm)	Status (L-Live) (D-dead)	No Injected	% Recovered	Fishing Time (hr)	Remarks
10/20-22	5	Rainbow	200-300	L	50	22	24-46	Live cars in use; heavy leaves; both nets had large holes when pulled; many fish recovered from body of net.
10/20-22	5	Largemouth	200-300	L	50	100	24	
10/20-22	5	Walleye	50-100	L	100	65	21	
10/20-22	5	Yellow Perch	50-100	L	100	79	20	
10/20-22	5	Largemouth	40-75	L	100	61	20	
10/20-22	3	Rainbow	200-300	L	50	28	23	Live cars in use; heavy leaves; nets OK when pulled; many fish recovered from net body.
10/20-22	3	Largemouth	200-300	L	50	46	22	
10/20-22	3	Walleye	50-100	L	100	30	8	
10/20-22	3	Yellow Perch	50-100	L	100	68	7	
10/20-22	3	Largemouth	40-75	L	100	51	7	
11/4	1	Mixture ²	150-290	D	50	52	26	Heavy net damage - upstream net.
11/16-18	1	Largemouth	151-300	L	86	74	42	Unit 1 operation reduced to 60% during injections; heavy net damage in upstream net; live cars not in use.
11/16-18	1	Smallmouth	176-325	L	14	71	42	
11/16-18	1	Largemouth	51-126	L	100	73	41	
11/16-18	1	Walleye	100-150	L	50	66	41	
11/16-18	1	Yellow Perch	76-125	L	100	78	41	
11/16-18	5	Largemouth	151-300	L	100	92	48	Live cars not in use; nets in good shape when pulled.
11/16-18	5	Largemouth	151-300	D	50	62	43	
11/16-18	5	Largemouth	51-126	L	100	65	48	
11/16-18	5	Yellow Perch	76-125	L	100	74	47	
11/16-18	5	Yellow Perch	76-125	D	50	84	43	
11/30-12/2	3	Largemouth	176-250	L	86	100	47	Live cars not in use; fish injected during darkness; nets pulled with unit operating at 100% gate.
11/30-12/2	3	Largemouth	51-175	L	100	95	48	
11/30-12/2	3	Yellow Perch	76-125	L	100	97	47	

¹ This table is presented for informational purposes only. Due to problems early in the study with net damage and development of techniques, the results of the fall 1993 efficiency tests were not used for data analysis.

² Mixture of dead largemouth and smallmouth bass and dead rainbow trout.

Table 4-8: Summary of efficiency test results, spring 1994,
Feeder Dam fish entrainment study.

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Test Species: Brown trout

Sample#	Injection Date	Unit No.	Treatment Effic.	Control Effic.
=====	=====	=====	=====	=====

-----Size Category 1 -----

038	05/26/94	1	38.0	48.0
039	06/07/94	3	19.0	21.9
043	06/15/94	5	57.1	56.5
045	06/22/94	1	56.4	40.3

Category estimate			40.5	40.6
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-----Size Category 3 -----

036	05/24/94	1	58.0	39.0
041	06/08/94	3	76.0	66.7
042	06/13/94	5	89.8	94.8
044	06/20/94	1	88.0	99.0

Category estimate			77.9	74.7
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Table 4-8: Summary of efficiency test results, spring 1994,
Feeder Dam fish entrainment study.

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Test Species: Golden shiner

Sample#	Injection Date	Unit No.	Treatment Effic.	Control Effic.
=====	=====	=====	=====	=====
-----Size Category 1 -----				
032	05/11/94	5	43.0	47.0
033	05/12/94	3	58.0	61.0
038	05/26/94	1	69.0	71.0
039	06/07/94	3	83.0	89.0
045	06/22/94	1	67.6	88.7

Category estimate			63.6	69.5

Table 4-8: Summary of efficiency test results, spring 1994,
Feeder Dam fish entrainment study.

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Test Species: Sunfishes

Sample#	Injection Date	Unit No.	Treatment Effic.	Control Effic.
=====	=====	=====	=====	=====
-----Size Category 1 -----				
038	05/26/94	1	90.3	98.9

Category estimate			90.3	98.9

Table 4-8: Summary of efficiency test results, spring 1994,
Feeder Dam fish entrainment study.

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Test Species: Bluegill

Sample#	Injection Date	Unit No.	Treatment Effic.	Control Effic.
=====	=====	=====	=====	=====

-----Size Category 1 -----				
036	05/24/94	1	89.9	74.2
039	06/07/94	3	89.0	92.0
043	06/15/94	5	88.0	94.0
045	06/22/94	1	61.4	90.0

Category estimate			81.8	87.9
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-----Size Category 3 -----				
032	05/11/94	5	98.0	93.0
033	05/12/94	3	65.0	84.0
041	06/08/94	3	73.0	67.0
042	06/13/94	5	94.0	94.0
044	06/20/94	1	39.0	75.0

Category estimate			73.8	82.6
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Table 4-8: Summary of efficiency test results, spring 1994,
Feeder Dam fish entrainment study.

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Test Species: Largemouth bass

Sample#	Injection Date	Unit No.	Treatment Effic.	Control Effic.
=====	=====	=====	=====	=====

-----Size Category 1 -----

034	05/17/94	3	98.0	77.0
035	05/18/94	5	83.0	90.0
038	05/26/94	1	85.1	82.0
039	06/07/94	3	75.0	87.0
043	06/15/94	5	70.0	89.9
045	06/22/94	1	60.0	86.0

Category estimate		78.7	85.1
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-----Size Category 2 -----

032	05/11/94	5	99.0	100.0
033	05/12/94	3	73.0	100.0
036	05/24/94	1	67.9	93.3
041	06/08/94	3	74.0	94.0
042	06/13/94	5	100.0	100.0
044	06/20/94	1	89.0	99.0

Category estimate		85.2	98.0
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-----Size Category 3 -----

041	06/08/94	3	82.0	94.1
042	06/13/94	5	90.0	100.0
044	06/20/94	1	93.9	100.0

Category estimate		88.0	97.8
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Table 4-8: Summary of efficiency test results, spring 1994,
Feeder Dam fish entrainment study.

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Test Species: Walleye

Sample#	Injection Date	Unit No.	Treatment Effic.	Control Effic.
=====	=====	=====	=====	=====

-----Size Category 1 -----

034	05/17/94	3	85.0	87.0
035	05/18/94	5	80.0	80.0
038	05/26/94	1	58.3	69.4

Category estimate			76.9	80.2
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-----Size Category 3 -----

032	05/11/94	5	95.0	95.0
033	05/12/94	3	98.3	93.3
036	05/24/94	1	95.0	87.2

Category estimate			96.3	92.5
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Table 4-8: Summary of efficiency test results, spring 1994,
Feeder Dam fish entrainment study.

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Test Species: Dead injected fish

Sample#	Injection Date	Unit No.	Treatment Effic.	Control Effic.
=====	=====	=====	=====	=====

-----Size Category 3 -----

034	05/17/94	3	100.0	
035	05/18/94	5	60.0	
038	05/26/94	1	100.0	
042	06/13/94	5	52.4	
045	06/22/94	1	98.0	

Category estimate 86.0

Report run date: 01/26/95 time: 11:20:05

TABLE 4-9
PROPOSED SPECIES AND SIZE GROUPINGS
FOR NET EFFICIENCY ADJUSTMENT FACTORS

	Average Efficiency by Species/Size Groups Tested	Efficiency Used in Entrainment Analysis ¹	No. of Tests
WEAK SWIMMING SPECIES Represented by: Golden Shiner	63.6%	63.6%	5
MODERATE SWIMMING SPECIES Represented by: Panfish - Bluegill (small) - Bluegill (large)	79.4% 76.2%	78.7%	3 6
Gamefish and Others - Largemouth bass (small) - Largemouth bass (medium) - Largemouth bass (large)	78.7% 85.2% 88.0%		6 6 3
STRONG SWIMMING SPECIES² Represented by: - Brown Trout (small) - Brown Trout (large)	40.5% 77.9%	40.5% 77.9%	4 4
DEAD FISH , Unidentified due to damage or decay Represented by: - Mixed species injections of dead test fish	86.0%	86.0%	5

¹ Species/size groups were further grouped according to results of the efficiency test, when average efficiencies were similar, in an effort to simplify data expansions.

² Walleye also tested, with high efficiencies (see Table 4-8), but health of test fish was questioned.

Table 4-10: Summary of mortality test results, spring 1994, Feeder Dam fish entrainment study.

Page: 1 of 6

Test Species: Brown trout

Sample#	Injection Date	Unit No.	=====Immediate=====			=====24-Hour=====			=====48-Hour=====		
			Treatment Survival	Control Survival	Adjusted Survival	Treatment Survival	Control Survival	Adjusted Survival	Treatment Survival	Control Survival	Adjusted Survival
			=====	=====	=====	=====	=====	=====	=====	=====	=====
-----			----- Size Category 1 -----			-----			-----		
038	05/26/94	1	81.6	81.3	100.4	78.9	81.3	97.2	78.9	79.2	99.7
039	06/07/94	3	52.6	47.6	110.5	52.6	42.9	122.8	42.1	42.9	98.2
043	06/15/94	5	62.5	74.4	84.1	5.0	15.4	32.5	5.0	15.4	32.5
045	06/22/94	1	59.1	74.2	79.6	11.4	6.5	176.1	6.8	0.0	
-----			-----			-----			-----		
Category average			65.2	72.7	89.8	33.3	40.3	82.7	30.5	38.1	80.0
-----			----- Size Category 3 -----			-----			-----		
036	05/24/94	1	60.3	59.0	102.3	60.3	56.4	107.0	20.7	12.8	161.4
041	06/08/94	3	80.3	95.6	84.0	68.4	73.5	93.1	31.6	41.2	76.7
042	06/13/94	5	80.7	91.3	88.4	47.7	47.8	99.8	45.5	32.6	139.4
044	06/20/94	1	77.3	62.6	123.4	2.3	11.1	20.5	0.0	0.0	
-----			-----			-----			-----		
Category average			75.8	78.5	96.5	42.3	42.6	99.2	24.5	21.1	116.0

Table 4-10: Summary of mortality test results, spring 1994, Feeder Dam fish entrainment study.

Test Species: Golden shiner

Sample#	Injection Date	Unit No.	=====Immediate=====			=====24-Hour=====			=====48-Hour=====		
			Treatment Survival	Control Survival	Adjusted Survival	Treatment Survival	Control Survival	Adjusted Survival	Treatment Survival	Control Survival	Adjusted Survival
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
-----			----- Size Category 1 -----			-----			-----		
032	05/11/94	5	30.2	53.2	56.8	9.3	29.8	31.2	9.3	29.8	31.2
033	05/12/94	3	46.6	36.1	129.1	39.7	32.8	120.9	39.7	31.1	127.3
038	05/26/94	1	92.8	95.8	96.8	92.8	94.4	98.3	91.3	90.1	101.3
039	06/07/94	3	77.1	60.7	127.1	61.4	31.5	195.3	32.5	20.2	160.8
045	06/22/94	1	44.0	76.6	57.4	12.0	48.9	24.5	0.0	21.3	0.0
-----			-----			-----			-----		
Category average			64.4	65.1	98.9	52.2	48.3	108.1	42.1	39.7	106.1

Table 4-10: Summary of mortality test results, spring 1994, Feeder Dam fish entrainment study.

Test Species: Sunfishes

Sample#	Injection Date	Unit No.	=====Immediate=====			=====24-Hour=====			=====48-Hour=====		
			Treatment	Control	Adjusted	Treatment	Control	Adjusted	Treatment	Control	Adjusted
			Survival	Survival	Survival	Survival	Survival	Survival	Survival	Survival	Survival
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	
-----			----- Size Category 1 -----			-----			-----		
038	05/26/94	1	79.6	79.3	100.3	67.7	74.7	90.7	58.1	64.4	90.2
-----			-----			-----			-----		
Category average			79.6	79.3	100.3	67.7	74.7	90.7	58.1	64.4	90.2

Table 4-10: Summary of mortality test results, spring 1994, Feeder Dam fish entrainment study.

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Test Species: Bluegill

Sample#	Injection Date	Unit No.	=====Immediate=====			=====24-Hour=====			=====48-Hour=====		
			Treatment Survival	Control Survival	Adjusted Survival	Treatment Survival	Control Survival	Adjusted Survival	Treatment Survival	Control Survival	Adjusted Survival
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
-----			----- Size Category 1 -----			-----			-----		
039	06/07/94	3	79.8	75.6	105.6	65.2	58.9	110.7	51.7	37.8	136.8
043	06/15/94	5	95.5	100.0	95.5	90.9	100.0	90.9	70.5	86.2	81.8
045	06/22/94	1	93.5	94.4	99.1	83.9	85.6	98.0	51.6	73.3	70.4
-----			-----			-----			-----		
Category average			89.1	90.1	98.9	79.5	81.8	97.2	58.6	66.1	88.7
-----			----- Size Category 3 -----			-----			-----		
032	05/11/94	5	87.8	98.9	88.7	87.8	98.9	88.7	86.7	97.8	88.6
033	05/12/94	3	89.2	95.2	93.7	89.2	84.5	105.6	84.6	82.1	103.0
036	05/24/94	1	75.0	92.4	81.1	71.3	90.9	78.4	66.3	72.7	91.1
041	06/08/94	3	95.9	100.0	95.9	91.8	97.0	94.6	56.2	59.7	94.1
042	06/13/94	5	98.9	100.0	98.9	97.9	97.9	100.0	61.7	67.0	92.1
044	06/20/94	1	97.4	98.7	98.8	46.2	46.7	98.9	28.2	16.0	176.3
-----			-----			-----			-----		
Category average			90.2	97.7	92.3	84.2	86.6	97.2	67.5	67.4	100.1

Table 4-10: Summary of mortality test results, spring 1994, Feeder Dam fish entrainment study.

Test Species: Largemouth bass

Sample#	Injection Date	Unit No.	=====Immediate=====			=====24-Hour=====			=====48-Hour=====		
			Treatment Survival	Control Survival	Adjusted Survival	Treatment Survival	Control Survival	Adjusted Survival	Treatment Survival	Control Survival	Adjusted Survival
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
-----			----- Size Category 1 -----			-----			-----		
034	05/17/94	3	42.9	55.8	76.7	20.4	32.5	62.9	17.3	27.3	63.6
035	05/18/94	5	84.3	88.9	94.9	80.7	87.8	92.0	79.5	84.4	94.2
038	05/26/94	1	82.5	64.6	127.6	78.8	50.0	157.5	66.3	34.1	194.0
039	06/07/94	3	86.7	86.2	100.5	74.7	79.3	94.1	73.3	67.8	108.1
043	06/15/94	5	89.3	88.7	100.6	39.3	43.7	90.0	28.6	22.5	126.8
045	06/22/94	1	95.0	96.5	98.4	80.0	82.6	96.9	43.3	48.8	88.7
-----			-----			-----			-----		
Category average			77.4	80.5	96.2	61.1	64.1	95.3	51.5	49.1	105.0
-----			----- Size Category 2 -----			-----			-----		
032	05/11/94	5	75.8	80.0	94.7	71.7	72.0	99.6	63.6	62.0	102.6
033	05/12/94	3	72.6	77.0	94.3	53.4	64.0	83.5	50.7	61.0	83.1
036	05/24/94	1	88.9	96.4	92.2	86.1	87.5	98.4	69.4	80.4	86.4
041	06/08/94	3	86.5	96.8	89.3	70.3	78.7	89.3	51.4	48.9	104.9
042	06/13/94	5	87.0	99.0	87.9	68.0	86.0	79.1	37.0	59.0	62.7
044	06/20/94	1	85.4	92.9	91.9	37.1	41.4	89.5	12.4	18.2	68.0
-----			-----			-----			-----		
Category average			82.2	89.8	91.5	62.4	70.3	88.8	44.8	53.0	84.5
-----			----- Size Category 3 -----			-----			-----		
041	06/08/94	3	80.5	100.0	80.5	80.5	100.0	80.5	78.0	91.7	85.1
042	06/13/94	5	91.1	100.0	91.1	91.1	100.0	91.1	80.0	98.0	81.6
044	06/20/94	1	87.1	97.0	89.8	67.7	84.8	79.8	67.7	84.8	79.8
-----			-----			-----			-----		
Category average			86.3	99.2	87.0	81.2	96.2	84.4	76.1	92.4	82.4

Table 4-10: Summary of mortality test results, spring 1994, Feeder Dam fish entrainment study.

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Test Species: Walleye

Sample#	Injection Date	Unit No.	=====Immediate=====			=====24-Hour=====			=====48-Hour=====		
			Treatment Survival	Control Survival	Adjusted Survival	Treatment Survival	Control Survival	Adjusted Survival	Treatment Survival	Control Survival	Adjusted Survival
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
			----- Size Category 1 -----			-----			-----		
034	05/17/94	3	38.8	44.8	86.6	16.5	24.1	68.2	16.5	24.1	68.2
035	05/18/94	5	60.0	78.8	76.2	51.2	67.5	75.9	47.5	63.7	74.5
038	05/26/94	1	80.0	72.1	111.0	77.1	65.1	118.5	68.6	46.5	147.4
Category average			54.5	63.3	86.1	41.0	49.0	83.6	38.0	43.8	86.7
			----- Size Category 3 -----			-----			-----		
032	05/11/94	5	22.8	12.3	185.7	17.5	8.8	200.0	14.0	5.3	266.7
033	05/12/94	3	42.4	66.1	64.1	32.2	53.6	60.1	28.8	48.2	59.8
036	05/24/94	1	60.5	73.5	82.3	60.5	73.5	82.3	42.1	38.2	110.1
Category average			39.6	46.9	84.4	33.8	40.8	82.7	26.6	29.3	91.0

Report run date: 01/26/95 time: 11:19:36

TABLE 4-11
FEEDER DAM
ACCEPTABLE MORTALITY TESTS - SPRING 1994
(Control Survival \geq 85%)

Sheet 1 of 3

Sample No.	Injection Date	Unit	Trt. ¹ S.O %	Cont. S.O %	Adj. S.O %	Trt. S.24 %	Cont. S.24 %	Adj. S.24 %	Trt. S.48 %	Cont. S.48 %	Adj. S.48 %
Brown Trout (Size Cat. 3)											
041	6/8/94	3	80.26	95.59	83.97	-----2-----					
042	6/13/94	5	80.68	91.30	88.37	-----					
Category Estimate			80.49	93.13	86.43						
Golden Shiner											
038	5/26/94	1	92.75	95.77	96.85	92.75	94.37	98.29	91.30	90.14	101.29
Bluegill (Size Cat. 1)											
043	6/15/94	5	95.45	100.00	95.45	90.91	100.00	90.91	70.45	86.17	81.76
045	6/22/94	1	93.55	94.44	99.05	83.87	85.56	98.03	-----		
Category Estimate			94.67	97.28	97.32	88.00	92.93	94.69	70.45	86.17	81.76
Bluegill (Size Cat. 3)											
032	5/11/94	5	87.76	98.92	88.71	87.76	98.92	88.71	86.73	97.85	88.64
033	5/12/94	3	89.23	95.24	93.69	-----					
036	5/24/94	1	75.00	92.42	81.15	71.25	90.91	78.38	-----		
041	6/8/94	3	95.89	100.00	95.89	91.78	97.01	94.60	-----		
042	6/13/94	5	98.94	100.00	98.94	97.87	97.87	100.00	-----		
044	6/20/94	1	97.44	98.67	98.75	-----					
Category Estimate			90.20	97.70	92.32	87.54	96.56	90.66	86.73	97.85	88.64

TABLE 4-11
FEEDER DAM
ACCEPTABLE MORTALITY TESTS - SPRING 1994
(Control Survival \geq 85%)

Sheet 2 of 3

Sample No.	Injection Date	Unit	Trt. S.O %	Cont. S.O %	Adj. S.O %	Trt. S.24 %	Cont. S.24 %	Adj. S.24 %	Trt. S.48 %	Cont. S.48 %	Adj. S.48 %
Largemouth (Size Cat. 1)											
035	5/18/94	5	84.34	88.89	94.88	80.72	87.78	91.96			
039	6/7/94	3	86.67	86.21	100.53						
043	6/15/94	5	89.29	88.73	100.62						
045	6/22/94	1	95.00	96.51	98.43						
Category Estimate			88.32	90.12	98.00	80.72	87.78	91.96			
Largemouth (Size Cat. 2)											
036	5/24/94	1	88.89	96.43	92.18	86.11	87.50	98.41			
041	6/8/94	3	86.49	96.81	89.34						
042	6/13/94	5	87.00	99.00	87.88	68.00	86.00	79.07			
044	6/20/94	1	85.39	92.93	91.89						
Category Estimate			86.62	96.28	89.97	72.79	86.54	84.11			
Largemouth (Size Cat. 3)											
041	6/8/94	3	80.49	100.00	80.49	80.49	100.00	80.49	78.05	91.67	85.14
042	6/13/94	5	91.11	100.00	91.11	91.11	100.00	91.11	80.00	98.00	81.63
044	6/20/94	1	87.10	96.97	89.82						
Category Estimate			86.32	99.24	86.98	86.05	100.00	86.05	79.07	94.90	83.22

TABLE 4-11
SUMMARY OF PERCENT MORTALITY BY TEST SPECIES GROUP

Species/Size Group	Immediate % Mortality	No. of Tests	24-Hour % Mortality	No. of Tests	48-Hour % Mortality	No. of Tests
- Weak swimmers	3.15%	1	1.71%	1	+ 1.29%	1
- Moderate swimmers						
- Panfish (small)	2.68%	2	5.31%	2	18.24%	1
- Panfish (large)	7.68%	6	9.34%	4	11.36%	1
- Bass (small)	2.00%	4	8.04%	1	--	--
- Bass (medium)	10.03%	4	15.89%	2	--	--
- Bass (large)	13.22%	3	13.95%	2	16.68%	2
- Strong swimmers						
- Trout (large)	13.57%	2	--	--	--	--

¹ Survival/mortality measured 0 hours, 24 hours, and 48 hours after net retrieval from the water. Actual injection of test fish occurred 24 hours prior to net retrieval.

² Dashed line indicates that no tests occurred that met control group survival criteria ($\geq 85\%$).

TABLE 4-12			
PROPOSED MORTALITY TESTS FOR USE IN MORTALITY ESTIMATES			
Representative Test Species	Mort. Rate	No. ¹ of Tests	Remarks
1 - CENTRARCHIDS:			
Panfish			
Bluegill (small)	.0531	2	Spring 1994 tests
Bluegill (large)	.0934	4	Spring 1994 tests
Bass			
Largemouth (small)	.0804	1	Spring 1994 tests
Largemouth (medium)	.1589	2	Spring 1994 tests
Largemouth (large)	.1395	2	Spring 1994 tests
2 - PERCIDS:			
Largemouth (small)	.0804	1	Spring 1994 tests
Largemouth (medium)	.1589	1	Spring 1994 tests
Largemouth (large)	.1395	2	Spring 1994 tests
3 - SALMONIDS:			
Brown Trout (large)	.1741	0	Spring 1994 test - using extrapolated "immediate" data ²
Largemouth bass (medium)	.1589	2	Spring 1994 tests
Largemouth bass (small)	.1395	2	Spring 1994 tests
4 - SOFT-RAYED:			
Golden shiner	.0171	1	Spring 1994 test
5 - AMERICAN EEL:			
No tests conducted, but one of the two eel collected (50%) was dead. Thus, use 50% mortality for American eel.			

NOTES:

¹ Valid tests are defined as those where control fish survival \geq 85%. These are the tests from fish held 24 hours after recovery from the nets.

² Rate extrapolated from "immediate" large trout data using the proportional increase in mortality rate for medium and large largemouth bass from "immediate" rates to 24-hour rates.

TABLE 4-13

**PROPOSED GROUPINGS FOR MORTALITY RATES
BASED ON FEEDER DAM DATABASE**

Group	Subgroup	Species	Represented by
Centrarchids (62.5% of total catch)	Panfish (56.1% of total catch)	Black crappie Bluegill Pumpkinseed Redbreast sunfish Rock Bass White crappie	Bluegill (large + small) (Spring 1994 tests)
	Bass (6.4% of total catch)	Largemouth bass Smallmouth bass	Largemouth bass (small, medium, large) (Spring 1994 tests)
Percids (8.1% of total catch)	--	Walleye Yellow Perch	Largemouth bass tests - Spring 1994
Salmonids (Includes Esocids bullheads/catfish and carp) (16.2% of total catch)	--	Brook trout Brown trout Rainbow trout Chain pickerel Northern pike Black bullhead Brown bullhead Channel catfish Carp Yellow bullhead	Brown trout (large) - Spring 1994 tests Largemouth bass (small and medium) - Spring 1994 tests
Soft-Rayed (10.9% of total catch)	--	Blacknose dace Bluntnose minnow Emerald shiner Fallfish Golden shiner Greenside darter Logperch Minnows, sp. Northern hogsucker Rainbow smelt Spottail shiner Tessellated darter White sucker	Golden shiner - Spring 1994 tests
American eel (0.1% of total catch)	No tests conducted - assume 50% mortality based on total catch of one dead and one live eel		

TABLE 4-14

**RANGE OF POTENTIAL MORTALITY RATES FOR SPECIES GROUPS
USED TO ESTIMATE TOTAL MORTALITY**

Based on Feeder Dam Mortality Tests*

SPECIES GROUPS	STRIKE LIVE CAR ESTIMATE ¹	ADJ. ALL CONTROL Non-Recov. = Alive ²	ADJ. 85% < = 100% ³	ACRES BEST ESTIMATE ⁴	TOTAL LIVE CAR ESTIMATE ⁵	ADJ. ALL CONTROL Non-Recov. = Dead ⁶	NO CONTROL ADJ. ⁷
<u>WEAK SWIMMERS</u>							
≤ 6"	0.0270	0.0100	0.0315	0.0171	0.2780	0.0450	0.0725
> 6"	0.0380	0.0100	0.0315	0.0171	0.1090	0.0450	0.0725
<u>MODERATE SWIMMERS</u>							
Panfish (small)	0.0270	0.0260	0.0268	0.0531	0.2780	0.2320	0.0533
Panfish (large)	0.0380	0.0850	0.0768	0.0934	0.1090	0.0230	0.0980
Bass (small)	0.0270	0.0560	0.0200	0.0804	0.2780	0.1520	0.1168
Bass (medium)	0.0380	0.1270	0.1003	0.1589	0.1090	0.2330	0.1338
Bass (large)	0.0380	0.1200	0.1302	0.1395	0.1090	0.2370	0.1368
<u>STRONG SWIMMERS</u>							
Trout (large)	0.0380	0.1440	0.1357	0.1741	0.1090	0.2740	0.1951
<u>UNKNOWN FISH REMAINS⁸</u>							
≤ 6"	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
> 6"	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
<u>AMERICAN EEL⁹</u>	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000

* Before application of Glens Falls adjustment factor.

- 1 - Mortality based on naturally entrained dead fish in live car with evidence of turbine related damage.
- 2 - Mortality adjusted for all controls where survival > = 85% using data for 24 hours after net retrieval, non-recovered assumed alive.
- 3 - Mortality adjusted for all controls where survival > = 85% using data for 0 hours after net retrieval, adjusted survivals > 100% assumed to be = 100%.
- 4 - Mortality adjusted for all controls where survival > = 85% using data for 24 hours after net retrieval, non-recovered assuming to survive in same proportion as recovered (i.e., no non-recovery adjustment).
- 5 - Mortality based on naturally entrained dead fish in live car with no adjustments (i.e., direct mortality of naturally entrained fish).
- 6 - Mortality adjusted for all controls where survival > = 85% using data for 24 hours after net retrieval, non-recovered assumed dead.
- 7 - Mortality not adjusted for controls, using data for 0 hours after net retrieval where survival in paired control group was > = 85%.
- 8 - All unknown fish remains are recovered dead.
- 9 - American eel rate based on total catch of one dead and one live eel.

TABLE 4-15

ESTIMATED FISH ENTRAINMENT BY MONTH AT THE
GLENS FALLS HYDROELECTRIC PROJECT

MONTH ¹	ESTIMATED ENTRAINMENT
JANUARY	507
FEBRUARY	1,661
MARCH	1,333
APRIL	7,079
MAY	6,664
JUNE	7,249
JULY	2,963
AUGUST	3,977
SEPTEMBER	3,197
OCTOBER	2,201
NOVEMBER	932
DECEMBER	983
ANNUAL TOTAL	38,746

¹January through October data is from 1994, November data is from both 1993 and 1994, and December data is from 1993.

TABLE 4-16
ESTIMATED ENTRAINMENT AND MORTALITY OF FISHES AT
GLENS FALLS PROJECT
NOVEMBER 1993 TO NOVEMBER 1994

SPECIES	NO. ENTRAINED	NO. KILLED	% KILLED
Rainbow trout	162	67	41.35
Brown trout	149	53	35.57
Brook trout	19	8	42.10
Rainbow smelt	949	38	4.00
Pikes (<i>Esox</i> , sp.)	53	10	18.86
Northern pike	45	8	17.78
Chain pickerel	190	59	31.05
Carps and Minnows (<i>Cyprinidae</i>)	581	23	3.96
Common carp	109	20	18.35
Golden shiner	2,346	93	3.96
Emerald shiner	304	12	3.95
Spottail shiner	72	3	4.17
Bluntnose minnow	28	1	3.57
Blacknose dace	10	<1	<0.10
Fallfish	193	8	4.15
Shiners (<i>Notropis</i> , sp.)	550	22	4.00
Dace	10	<1	<0.10
Minnows (<i>Pimephales</i> , sp.)	70	3	4.29
Northern hogsucker	9	<1	<0.11
Bullheads/catfishes (<i>Ictalurus</i> , sp.)	822	155	18.86
Yellow bullhead	3,364	640	19.02
Brown bullhead	761	151	19.84
Channel catfish	123	23	18.70
Sunfishes (<i>Centrarchidae</i>)	465	57	12.26
Rock bass	5,737	1,181	20.59
Redbreast sunfish	6,482	1,274	19.65
Pumpkinseed	3,636	621	17.08
Bluegill	448	59	13.17

TABLE 4-16
ESTIMATED ENTRAINMENT AND MORTALITY OF FISHES AT
GLENS FALLS PROJECT
NOVEMBER 1993 TO NOVEMBER 1994

SPECIES	NO. ENTRAINED	NO. KILLED	% KILLED
Smallmouth bass	1,093	329	30.10
Largemouth bass	1,392	271	19.47
White crappie	13	2	15.38
Black crappie	210	29	13.81
Sunfish (<i>Lepomis</i> , sp.)	4,366	538	12.32
Darters	19	1	5.26
Tesselated darter	780	31	3.97
Yellow perch	2,591	680	26.24
Logperch	150	6	4.00
Walleye	145	30	20.69
Unknown fish remains	300	300	100.00
TOTAL	38,746	6,807	17.57

¹Total may differ from Table 4-15 and Appendix E due to rounding.

TABLE 4-17
GLENS FALLS PROJECT
SUMMARY OF FISH MORTALITY ESTIMATES
EXISTING RACKS WITH 1-5/8" BAR SPACING

SPECIES GROUPS	STRIKE LIVE CAR ESTIMATE ¹	ADJ. ALL CONTROL Non-Recov. = Alive ²	ADJ. 85% < = 100% ³	ACRES BEST ESTIMATE ⁴	TOTAL LIVE CAR ESTIMATE ⁵	ADJ. ALL CONTROL Non-Recov. = Dead ⁶	NO CONTROL ADJ. ⁷
Rainbow trout	16.1	53.9	42.6	67.4	46.2	98.9	56.8
Brown trout	12.7	42.0	33.3	52.6	44.0	79.4	48.5
Brook trout	1.7	6.4	6.0	7.8	4.9	12.2	8.7
Rainbow smelt	59.8	22.0	69.4	37.7	606.8	99.1	159.7
Pikes	3.3	6.9	2.5	9.9	34.3	18.7	14.4
Northern pike	2.8	5.9	2.1	8.4	29.1	15.9	12.2
Chain pickerel	15.1	45.8	33.3	58.7	73.3	91.8	58.2
Carps and minnows	36.4	13.5	42.4	23.0	374.4	60.6	97.6
Common carp	6.8	14.1	5.1	20.3	70.2	38.4	29.5
Golden shiner	150.8	54.4	171.5	93.1	1455.3	245.0	394.7
Emerald shiner	19.0	7.0	22.2	12.0	195.8	31.7	51.1
Spottail shiner	4.5	1.7	5.2	2.8	46.2	7.5	12.1
Bluntnose minnow	1.8	0.7	2.1	1.1	18.1	2.9	4.7
Blacknose dace	0.6	0.2	0.8	0.4	6.7	1.1	1.7
Fallfish	12.3	4.5	14.1	7.7	121.6	20.2	32.5
Shiners	34.5	12.8	40.2	21.8	354.8	57.4	92.5
Dace	0.6	0.2	0.8	0.4	6.7	1.1	1.7
Minnows	4.4	1.6	5.1	2.8	45.4	7.3	11.8
Northern hogsucker	0.6	0.2	0.7	0.4	5.8	0.9	1.5
Bullheads/Catfishes	51.8	108.7	40.3	155.4	525.3	291.9	223.1
Yellow bullhead	212.4	448.1	168.6	639.7	2143.5	1198.9	914.2
Brown bullhead	48.9	107.1	44.7	151.1	471.0	277.7	208.1
Channel catfish	7.7	15.9	5.7	22.8	79.0	43.2	33.2
Sunfishes	29.1	28.1	28.9	57.3	300.1	250.4	57.5
Rock bass	488.8	1040.4	945.1	1181.1	1711.5	628.5	1235.5
Redbreast sunfish	535.8	1087.4	993.2	1274.2	2185.6	1021.7	1329.1
Pumpkinseed	275.0	473.0	441.0	621.2	1618.4	1058.4	641.8
Bluegill	29.1	32.8	32.7	59.1	272.3	220.6	59.8
Smallmouth bass	86.1	255.9	181.0	329.4	432.8	515.8	323.5

TABLE 4-17
GLENS FALLS PROJECT
SUMMARY OF FISH MORTALITY ESTIMATES
EXISTING RACKS WITH 1-5/8" BAR SPACING

SPECIES GROUPS	STRIKE LIVE CAR ESTIMATE ¹	ADJ. ALL CONTROL Non-Recov. = Alive ²	ADJ. 85% < = 100% ³	ACRES BEST ESTIMATE ⁴	TOTAL LIVE CAR ESTIMATE ⁵	ADJ. ALL CONTROL Non-Recov. = Dead ⁶	NO CONTROL ADJ. ⁷
Largemouth bass	89.2	192.7	82.4	271.4	867.8	505.9	380.6
White crappie	0.8	0.8	0.8	1.6	8.3	6.9	1.6
Black crappie	13.9	16.5	16.3	28.5	124.0	99.0	28.9
Sunfish	273.5	263.3	271.4	537.8	2815.8	2349.8	539.9
Darters	1.2	0.4	1.4	0.8	12.3	2.0	3.2
Tessellated darter	48.8	18.1	57.0	30.9	502.9	81.4	131.2
Yellow perch	189.9	514.4	321.3	679.9	1248.1	1116.6	744.7
Logperch	9.4	3.5	11.0	6.0	97.0	15.7	25.3
Walleye	9.5	21.4	9.6	29.9	87.7	54.2	40.0
Unknown fish remains	300.3	300.3	300.3	300.3	300.3	300.3	300.3
TOTAL	3085.2	5222.8	4452.0	6806.7	19343.1	10928.9	8311.5
VALUE	\$3,307	\$7,595	\$6,097	\$9,402	\$15,936	\$11,848	\$9,969

- 1 - Mortality based on naturally entrained dead fish in live car with evidence of turbine related damage.
- 2 - Mortality adjusted for all controls where survival > = 85% using data for 24 hours after net retrieval, non-recovered assumed alive.
- 3 - Mortality adjusted for all controls where survival > = 85% using data immediately after net retrieval, adjusted survivals > 100% assumed to be = 100%.
- 4 - Mortality adjusted for all controls where survival > = 85% using data for 24 hours after net retrieval, non-recovered assuming to survive in same proportion as recovered (i.e., no non-recovery adjustment).
- 5 - Mortality based on naturally entrained dead fish in live car with no adjustments (i.e., direct mortality of naturally entrained fish).
- 6 - Mortality adjusted for all controls where survival > = 85% using data for 24 hours after net retrieval.
- 7 - Mortality not adjusted for controls, using data immediately after net retrieval where survival in paired control group was > = 85%, non-recovered assumed dead.

TABLE 4-18
GLENS FALLS PROJECT
SUMMARY OF FISH MORTALITY ESTIMATES
RACKS WITH 1" BAR SPACING

SPECIES GROUPS	STRIKE LIVE CAR ESTIMATE ¹	ADJ. ALL CONTROL Non-Recov. = Alive ²	ADJ. 85% <= 100% ³	ACRES BEST ESTIMATE ⁴	TOTAL LIVE CAR ESTIMATE ⁵	ADJ. ALL CONTROL Non-Recov. = Dead ⁶	NO CONTROL ADJ. ⁷
Rainbow trout	4.9	16.3	12.8	20.3	14.0	29.8	17.1
Brown trout	7.8	24.9	18.8	31.6	30.0	47.6	28.4
Brook trout	1.7	6.6	6.0	7.8	4.9	12.2	8.7
Rainbow smelt	59.8	22.0	69.4	37.7	606.8	99.1	159.7
Pikes	3.3	6.9	2.5	9.9	34.3	18.7	14.4
Northern pike	2.8	5.9	2.1	8.4	29.1	15.9	12.2
Chain pickerel	13.9	41.5	29.2	53.5	70.0	83.5	52.4
Carp and minnows	36.4	13.5	42.4	23.0	374.4	60.6	97.6
Common carp	6.8	14.1	5.1	20.3	70.2	38.4	29.5
Golden shiner	149.1	54.0	170.1	92.3	1450.5	243.0	391.5
Emerald shiner	19.0	7.0	22.2	12.0	195.8	31.7	51.1
Spottail shiner	4.5	1.7	5.2	2.8	46.2	7.5	12.1
Bluntnose minnow	1.8	0.7	2.1	1.1	18.1	2.9	4.7
Blacknose dace	0.6	0.2	0.8	0.4	6.7	1.1	1.7
Fallfish	12.3	4.5	14.1	7.7	121.6	20.2	32.5
Shiners	34.5	12.8	40.2	21.8	354.8	57.4	92.5
Dace	0.6	0.2	0.8	0.4	6.7	1.1	1.7
Minnows	4.4	1.6	5.1	2.8	45.4	7.3	11.8
Northern hogsucker	0.6	0.2	0.7	0.4	5.8	0.9	1.5
Bullheads/Catfishes	50.7	105.2	37.6	151.1	522.4	285.6	219.5
Yellow bullhead	203.6	422.3	150.8	606.3	2096.4	1146.2	880.8
Brown bullhead	39.8	86.5	35.4	122.2	386.8	225.6	169.7
Channel catfish	7.7	15.9	5.7	22.8	79.0	43.2	33.2
Sunfishes	29.1	28.1	28.9	57.3	300.1	250.4	57.5
Rock bass	268.5	548.6	500.7	640.0	1074.3	489.4	667.8
Redbreast sunfish	426.7	843.2	772.5	1005.8	1872.4	955.6	1047.5
Pumpkinseed	182.2	266.1	254.1	393.2	1346.7	996.5	402.7
Bluegill	29.1	32.8	32.7	59.1	272.3	220.6	59.8
Smallmouth bass	50.1	139.2	90.0	182.6	308.4	295.8	194.1

TABLE 4-18
GLENS FALLS PROJECT
SUMMARY OF FISH MORTALITY ESTIMATES
RACKS WITH 1" BAR SPACING

SPECIES GROUPS	STRIKE LIVE CAR ESTIMATE ¹	ADJ. ALL CONTROL Non-Recov. = Alive ²	ADJ. 85% < = 100% ³	ACRES BEST ESTIMATE ⁴	TOTAL LIVE CAR ESTIMATE ⁵	ADJ. ALL CONTROL Non-Recov. = Dead ⁶	NO CONTROL ADJ. ⁷
Largemouth bass	84.1	176.6	65.5	252.5	853.2	474.3	362.4
White crappie	0.8	0.8	0.8	1.6	8.3	6.8	1.6
Black crappie	11.3	10.9	11.3	22.3	116.8	97.5	22.4
Sunfish	273.5	263.3	271.4	537.8	2815.8	2349.8	539.9
Darters	1.2	0.4	1.4	0.8	12.3	2.0	3.2
Tessellated darter	48.8	18.1	57.0	30.9	502.9	81.4	131.2
Yellow perch	147.9	374.0	210.4	504.2	1127.7	859.0	596.8
Logperch	9.4	3.5	11.0	6.0	97.0	15.7	25.3
Walleye	9.5	21.4	9.6	29.9	87.7	54.2	40.0
Unknown fish remains	289.9	289.9	289.9	289.9	289.9	289.9	289.9
TOTAL	2528.9	3881.2	3286.1	5270.7	17655.4	9918.7	6766.4
VALUE	\$2,157	\$4,481	\$3,437	\$5,727	\$12,506	\$8,237	\$6,481

- 1 - Mortality based on naturally entrained dead fish in live car with evidence of turbine related damage.
- 2 - Mortality adjusted for all controls where survival > = 85% using data for 24 hours after net retrieval, non-recovered assumed alive.
- 3 - Mortality adjusted for all controls where survival > = 85% using data immediately after net retrieval, adjusted survivals > 100% assumed to be = 100%.
- 4 - Mortality adjusted for all controls where survival > = 85% using data for 24 hours after net retrieval, non-recovered assuming to survive in same proportion as recovered (i.e., no non-recovery adjustment).
- 5 - Mortality based on naturally entrained dead fish in live car with no adjustments (i.e., direct mortality of naturally entrained fish).
- 6 - Mortality adjusted for all controls where survival > = 85% using data for 24 hours after net retrieval.
- 7 - Mortality not adjusted for controls, using data immediately after net retrieval where survival in paired control group was > = 85%, non-recovered assumed dead.

TABLE 4-19
GLENS FALLS PROJECT
SUMMARY OF BENEFITS, IN VALUE OF FISH "SAVED",
FOR INSTALLATION OF ONE-INCH SPACED TRASHRACKS
AT THE RANGE OF POTENTIAL MORTALITY RATES AT GLENS FALLS

SCENARIO	STRIKE LIVE CAR ESTIMATE ¹	ADJ. ALL CONTROL Non-Recov. = Alive ²	ADJ. 85% <= 100% ³	ACRES BEST ESTIMATE ⁴	TOTAL LIVE CAR ESTIMATE ⁵	ADJ. ALL CONTROL Non-Recov. = Dead ⁶	NO CONTROL ADJ. ⁷
Value of fish killed under existing conditions	\$ 3,307	\$ 7,595	\$ 6,097	\$ 9,402	\$15,936	\$11,848	\$ 9,969
Value of fish killed after installation of one-inch racks	\$ 2,157	\$ 4,481	\$ 3,437	\$ 5,727	\$12,506	\$ 8,237	\$ 6,481
Benefit of one-inch racks	\$ 1,150	\$ 3,114	\$ 2,660	\$ 3,675	\$ 3,430	\$ 3,611	\$ 3,488

- 1 - Mortality based on naturally entrained dead fish in live car with evidence of turbine related damage.
- 2 - Mortality adjusted for all controls where survival > = 85% using data for 24 hours after net retrieval, non-recovered assumed alive.
- 3 - Mortality adjusted for all controls where survival > = 85% using data immediately after net retrieval, adjusted survivals > 100% assumed to be = 100%.
- 4 - Mortality adjusted for all controls where survival > = 85% using data for 24 hours after net retrieval, non-recovered assuming to survive in same proportion as recovered (i.e., no non-recovery adjustment).
- 5 - Mortality based on naturally entrained dead fish in live car with no adjustments (i.e., direct mortality of naturally entrained fish).
- 6 - Mortality adjusted for all controls where survival > = 85% using data for 24 hours after net retrieval.
- 7 - Mortality not adjusted for controls, using data immediately after net retrieval where survival in paired control group was > = 85%, non-recovered assumed dead.

5 DISCUSSION AND RECOMMENDATIONS

The one-year fish entrainment investigation indicated that the annual passage at the Glens Falls Project is 38,746 fish, or an overall passage rate of only about 4 fish per hour through the entire station. The "best estimate" for mortality during passage was 6,807 fish for the 12 months, or about 0.8 fish per hour. Although the significance of these numbers can be somewhat subjective depending upon one's perspective, these estimates demonstrate that fish entrainment at the Glens Falls Project is minor. Any assessment of the significance of this level of entrainment, however, must take into account the highly conservative nature of these estimates, and the results of entrainment studies conducted on other projects.

5.1 Factors Leading to Highly Conservative Estimates

During the conduct of the study, some factors were noted that would result in conservative biases being incorporated into the entrainment and mortality estimates. It is important to discuss these factors so that the conservative skew of the estimates reported herein can be understood. The factors are outlined as follows:

- Escapement of unmarked test fish upstream of the powerhouse during holding and marking procedures, and later entrainment and capture during sampling would bias the estimate upwards, because these fish cannot be distinguished from naturally entrained fish.
- During efficiency testing, injected fish were observed swimming back and forth upstream in front of the trashracks. These fish would never be captured if they swam into the forebay and remained there. The uncaptured treatment fish reduce the efficiency correction factor for entrained fish. The assumption that all injected fish are entrained in the unit of injection during the 24-hour test would be violated. A lower efficiency correction factor would bias the entrainment estimate upward.
- During efficiency testing, fish injected into one unit were captured in the entrainment net of another unit. The most likely explanation is that the fish swam upstream from the point of injection through the trashrack and into the neighboring unit. This fish behavior reduces the efficiency correction factor for one or more of the units and biases the entrainment estimate upward (see above).
- Net intrusion of tailrace fish during the deployment process biases the entrainment estimates upward. Even though known net intrusion fish (i.e., those recaptured with tags) were removed from the sample population, actual net intrusion is most likely occurring at a higher rate than indicated by tag returns, because not all tailrace fish

are tagged. Net intrusion inflates the raw entrainment catch, and in turn the entrainment estimate.

- During winter sampling, several fish were captured that appeared to have been dead for a long period of time and were most likely carried downstream into the powerhouse as dead fish. These fish do not represent actual entrained fish, but organic debris floating free in the river. These fish, however, were counted as entrained, and would bias the entrainment estimates upward.
- Throughout the study, several fish were captured as unidentified (decayed) fish remains. These fish also appeared to have been dead for a long period of time before entrainment sampling. They were counted as entrained fish and would bias the estimated entrainment upward.

5.2 Comparisons with Other Entrainment Studies

To put the results of the Feeder Dam/Glens Falls fish entrainment study into perspective, related to other fish entrainment studies, the 1992 EPRI report, "Fish Entrainment and Turbine Mortality Review and Guidelines", was reviewed. The results of that review are discussed as follows:

- Fish passage rates ranged from 1 to 10 fish per hour for the studies reported in the EPRI (1992) report. The entrainment rate for the Feeder Dam Project was 6 fish per hour, which is the mid-range of the EPRI reported studies.
- Turbine mortality data reviewed in the EPRI report did not indicate any large differences in mortality between various types of species evaluated. Mortality rates calculated for the Feeder Dam Project ranged from 2 percent to 17 percent and did increase by swimming strength from smaller weak swimmers to larger strong swimmers.
- According to the EPRI report, mortality of naturally entrained resident fish was as low as 1 to 2 percent and averaged 6 percent at both Francis and Kaplan turbines. Feeder Dam mortality estimates for naturally entrained resident fish ranged from 3 to 4 percent for fish with evidence of turbine strike, and 11 to 28 percent for all sources of entrainment sampling mortality including turbine mortality, handling stress, and netting mortality.
- According to the EPRI report, mortality rates of artificially introduced fish were 10 to 30 percent. These rates were for tests not corrected for control mortality. Feeder Dam mortality rates for artificially introduced fish with no correction for controls ranged from 5 to 20 percent.

- Of the studies reported in the EPRI report, small or young-of-year fish generally comprised a large portion of the fish entrained. In many cases, 90 percent of the fish captured were less than 100 mm, and in nearly all reported studies 90 percent of the fish captured were less than 200 mm. The Feeder Dam study indicates 46 percent of captured fish were less than 100 mm, and 87 percent were less than 200 mm.
- The EPRI report identified that entrainment was usually highest in the late spring and summer, and was consistently low in the winter and early spring. Results from Feeder Dam were consistent with these findings.

In summary, the results from the Feeder Dam/Glens Falls study were similar to results of many of the studies presented in EPRI (1992). Within the next several months, the results of ongoing Niagara Mohawk studies will become available, and the combined results from the Feeder Dam/Glens Falls study and these other studies will provide a good information base on the significance of fish entrainment and mortality at hydroelectric projects on the Hudson River and elsewhere in New York State.

5.3 Recommendations

In comparing the potential benefits of installing fish protection structures at the Glens Falls Project to the costs of that installation, it becomes obvious that costs of fish protective structures greatly outweigh the benefits to be gained by constructing such structures, based on the value of fish that would be protected.

The installation of fish protective measures would afford some incremental level of protection beyond the documented survival of fish passing through the Glens Falls project powerhouse. The cost of installing such measures to obtain this incremental level of protection, however, is difficult to justify. Further, the loss of fish through turbine entrainment and mortality does not suggest a potential for significantly affecting the fishery resources of the project reach of the Hudson River, based on the species and size of fish entrained. The resident fish population in the project area appears to be a diverse warmwater/coolwater community typical of the upper Hudson River, and does not include any threatened, endangered, or other species that could be adversely affected by continued operation of the project.

Consequently, installation of enhancement measures to protect fish from entrainment or impingement are not recommended.

An alternative enhancement measure that could be considered, however, for the low numbers of fish that are killed during passage through the project, would be to make an annual payment to the State of New York equal to the value of fish killed during passage.

The fish values used to develop this annual payment should be based on fish values published by the American Fisheries Society or other impartial, independent source. Such an annual payment could in turn be used by the State in stocking programs, other programs to enhance recreational fishing opportunities in the State, or for other purposes.

6 DOCUMENTATION OF AGENCY CONSULTATION

6.1 - General Description of Consultations

The USFWS and NYSDEC were consulted throughout the entire study process, and were active participants in the process, through attendance at meetings, phone contacts, and other correspondence. Initial agency contacts were established in March 1993, shortly after the FERC issued the additional information request (AIR). The applicant presented and discussed several alternatives with the agencies related to the FERC AIR. The selected option was to conduct a fish entrainment study at Feeder Dam, which would represent conditions at both the Feeder Dam and Glens Falls projects. During the study, biweekly facsimiles were provided to the agencies, detailing the next week's study activities. Meetings and other contacts occurred throughout the study to provide the agencies with study progress, and to solicit agency input on study design and techniques. USFWS and NYSDEC input included reviewing and commenting on all data collections and procedures for entrainment sampling, efficiency and mortality testing. Table 6-1 summarizes agency consultations, and copies of meeting minutes, letters, and other correspondence are included in Appendix F.

6.2 - Consultations Related to the Final Report

The draft of the final report was issued to the USFWS and NYSDEC on December 9, 1994, with a request for the agencies' review and comments within 30 days. During this one-month review period, an interagency meeting was also scheduled (December 21, 1994), in which the agencies' preliminary comments on the draft report could be discussed. The preliminary agency comments on the report were discussed at the December 21, 1994 meeting, and it was agreed that the comments offered by the agencies at this meeting would serve as the agency comments on the draft report. Acres prepared minutes of the meeting to document the discussions, and these minutes were issued to the agencies for their review on January 6, 1995 (see Appendix F). The agencies also indicated, however, that they would likely file additional comments with FERC after receiving the final report.

In general, agency comments received on the draft report at the December 21, 1994 meeting were thoroughly discussed, and in many cases, the Applicant agreed to implement changes in the report as suggested by the agencies. A summary of the agency comments made at the meeting, and the Applicant's response, is included as Table 6-2.

TABLE 6-1

SUMMARY OF AGENCY CONSULTATIONS FROM MARCH 1993 THROUGH JANUARY 1995

Page 1 of 5

Date	Form	To	From	Subject
3/15/93	Letter	USFWS (Steve Patch)	Moreau (Kenneth Oriole)	Commencement of agency consultation period. Discusses feasibility analysis for proposed enhancements.
3/26/93	Meeting	USFWS (Steve Patch) NYSDEC (Edward Miller, Tim Post)	Moreau (Kenneth Oriole) Acres (Robert Eggink)	Proposed alternatives to FERC additional information request including fish entrainment sampling at Feeder Dam.
3/29/93	Telephone conversation	USFWS (Steve Patch)	Acres (Peter Foote)	Request for agency consultation meeting for fish entrainment studies.
3/30/93	Telephone conversation	NYSDEC (Edward Miller)	Acres (Peter Foote)	Request for agency consultation meeting for fish entrainment studies.
4/8/93	Meeting	USFWS (Steve Patch) NYSDEC (Edward Miller, Tim Post, Bill Schoch)	Finch, Pruyn (David Manny, Bob Swift) Moreau (Kenneth Oriole) Acres (Robert Eggink, Peter Foote)	Discussed fish entrainment studies for Glens Falls and the Feeder Dam Hydroelectric project.
5/05/93	Letter	Finch, Pruyn (David Manny)	USFWS (Leonard Corin)	Review of Joint Study Plan for Fish Entrainment at Feeder Dam along with the USFWS proposed approach.
5/18/93	Letter	Moreau (Kenneth Oriole)	NYSDEC (Edward Miller)	Commented on 3/26/93 meeting and the fish entrainment study plan.
6/11/93	Letter	Moreau (Kenneth Oriole)	USFWS (David Stilwell)	Review of Joint Study Plan for Fish Entrainment at Feeder Dam
9/9/93	Letter	USFWS (Steve Patch) NYSDEC (Edward Miller)	Acres (Robert Eggink)	Provided copies of Feeder Dam Fish Entrainment and Mortality Detailed Study Plan
9/17/93	Letter	Acres (Robert Eggink)	USFWS (David Stilwell)	Review of Fish Entrainment and Mortality Test Detailed Study Plan

TABLE 6-1

SUMMARY OF AGENCY CONSULTATIONS FROM MARCH 1993 THROUGH JANUARY 1995

Page 2 of 5

Date	Form	To	From	Subject
9/22/93	Letter	Acres (Robert Eggink)	NYSDEC (Edward Miller)	Review of Fish Entrainment and Mortality Test Detailed Study Plan
9/30/93	Meeting	USFWS (Steve Patch) NYSDEC (Edward Miller, Tim Post)	Finch, Pruyn (Bob Swift) Moreau (Kenneth Oriole) Acres (Robert Eggink, Larry Miller)	Coordinated and reviewed Fisheries Entrainment Study procedures and proposed schedule of sampling.
10/21/93	Letter	Acres (Robert Eggink)	NYSDEC (Edward Miller)	Provided list of endangered, threatened, and special concern species of fish.
11/03/93	Meeting	USFWS (Steve Patch) NYSDEC (Edward Miller, Tim Post)	Finch, Pruyn (Bob Swift) Moreau (Kenneth Oriole) Acres (Robert Eggink, Larry Miller, Peter Foote)	Reviewed results to date of entrainment sampling and efficiency and mortality testing. Discussed/resolved issues related to results, and discussed future sampling and testing schedule.
11/09/93	Letter	Acres (Robert Eggink)	NYSDEC (Edward Miller)	Reviewed meeting minutes, accepted revised sampling schedule with October sampling to be conducted in 1994.
12/6/93	Letter	Acres (Robert Eggink)	USFWS (David Stilwell)	Review of Quarterly Report No.3
1/20/94	Meeting	USFWS (Steve Patch) NYSDEC (Tim Post)	Finch, Pruyn (Bob Swift), Moreau (Kenneth Oriole) Acres (Robert Eggink, Larry Miller, Peter Foote)	Discussed a plan for further entrainment sampling efficiency studies in the spring, data handling, extrapolation, and a schedule for further winter sampling.
1/21/94	Letter	USFWS (Steve Patch) NYSDEC (Tim Post)	Acres (Robert Eggink)	Alternative winter schedule, canceling 1st January and both February sample events and substituting December data.

TABLE 6-1

SUMMARY OF AGENCY CONSULTATIONS FROM MARCH 1993 THROUGH JANUARY 1995

Page 3 of 5

Date	Form	To	From	Subject
1/25/94	Letter	Acres (Robert Eggink)	USFWS (David Stilwell)	Winter sampling collections/ change in schedule
2/8/94	Letter	Acres (Peter Foote)	USFWS (Steve Patch)	Discuss minutes of meeting additions and corrections
2/22/94	Telephone conversation	Acres (Peter Foote)	NYSDEC (Tim Post)	Test fish for Spring 1994 Efficiency and Mortality studies. Black crappie were to be used for mortality only and not efficiency.
3/21/94	Letter	Acres (Robert Eggink)	USFWS (David Stilwell)	Comments on Field Procedures Manual
4/06/94	Letter	USFWS (Steve Patch) NYSDEC (Tim Post)	Acres (Robert Eggink)	Preliminary results for March 1994 Entrainment Sampling.
4/08/94	Telephone conversation	USFWS (Steve Patch)	Acres (Peter Foote)	Telephone conversation addressing comments on Field Procedures Manual
4/14/94	Letter	USFWS (David Stilwell)	Acres (Robert Eggink)	Addressing comments to 3/21/94 letter commenting on Field Procedures Manual
4/27/94	Letter	USFWS (David Stilwell) NYSDEC (Tim Post)	Acres (Robert Eggink)	Efficiency and mortality testing- water temperatures and size groups
5/23/94	Telephone conversation	NYSDEC (Tim Post)	Acres (Peter Foote)	Discussed species of fish to be used for efficiency and mortality tests. T.Post indicated that brown trout and bluegill sunfish were acceptable test fish species.

TABLE 6-1

SUMMARY OF AGENCY CONSULTATIONS FROM MARCH 1993 THROUGH JANUARY 1995

Page 4 of 5

Date	Form	To	From	Subject
5/23/94	Telephone conversation	USFWS (Steve Patch)	Acres (Peter Foote)	Discussed species of fish to be used for efficiency and mortality tests. S.Patch indicated that brown trout and bluegill sunfish were acceptable test fish species.
6/07/94	On-site Meeting	NYSDEC (Tim Post)	Acres (Dale Miklas, Larry Miller)	Tim Post observed entrainment sampling and discussed problem of fykes in the tunnel of the nets between the body and live-car portions. T.Post agreed that the fykes were a problem and should be removed.
8/04/94	Letter	USFWS (Steve Patch) NYSDEC (Tim Post)	Acres (Robert Eggink)	Results of spring efficiency and mortality tests
9/08/94	Meeting	USFWS (Steve Patch, Kevin Moody) NYSDEC (Tim Post, Edward Miller)	Finch, Pruyn (David Manny, Bob Swift) Acres (Robert Eggink, Peter Foote, Dale Miklas)	Agencies (USFWS and NYSDEC) observed ongoing entrainment sampling activities. Acres provided them with a summary of entrainment catch through July 1994 and copies of proposed efficiency and latent mortality calculations.
9/29/94	Letter	USFWS (Steve Patch) NYSDEC (Tim Post)	Acres (Robert Eggink)	Provided data collected to date as well as a list of Spring 1994 mortality tests that met USFWS criteria of control fish survival equal to or greater than 85%.
10/05/94	Letter	Acres (Robert Eggink)	NYSDEC (Edward Miller)	Agree that literature values from NMPC studies would be inappropriate if applied at the Feeder Dam project.

TABLE 6-1

SUMMARY OF AGENCY CONSULTATIONS FROM MARCH 1993 THROUGH JANUARY 1995

Page 5 of 5

Date	Form	To	From	Subject
11/03/94	Letter	USFWS (Steve Patch) NYSDEC (Tim Post)	Acres (Robert Eggink)	Proposed swimming speed classifications and mortality rates for use in mortality estimates.
11/10/94	Letter	Acres (Robert Eggink)	USFWS (David Stilwell)	Comments on efficiency and mortality tests
11/10/94	Letter	Acres (Robert Eggink)	USFWS (David Stilwell)	Discussed fish mortality calculations, set control survival at minimum 85%
11/16/94	Letter	USFWS (David Stilwell)	Acres (Robert Eggink)	Response to 11/10/94 letter from USFWS. Provides species groupings for mortality rates and agrees to include "immediate" mortality rates, even though they should be identified as 24 hours after injection.
11/29/94	Facsimile	USFWS (Steve Patch) NYSDEC (Edward Miller)	Acres (Robert Eggink)	Arrangements, agenda and map for meeting to take place at 10:00 a.m. on Wednesday, December 21, 1994.
12/21/94	Meeting	USFWS (Steve Patch and Kevin Moody) NYSDEC (Edward Miller and Tim Post)	Finch, Pruyn (David Manny and Bob Swift) Moreau (Kenneth Oriole) Acres (Robert Eggink, Peter Foote and Larry Miller)	Reviewed results of fish entrainment study as reported in draft report sent to the agencies on December 9, 1994, and to discuss any preliminary agency comments on the draft report.
				Minutes of the meeting are enclosed in the January 6, 1995 facsimile.
1/6/95	Facsimile	USFWS (Steve Patch and Kevin Moody) NYSDEC (Edward Miller and Tim Post)	Acres (Robert Eggink)	Provided the Agencies with copies of the Minutes of Meeting from December 21, 1994 for review and comments.

TABLE 6-2
SUMMARY OF AGENCY COMMENTS RECEIVED AT THE
DECEMBER 21, 1994 INTERAGENCY MEETING IN
UTICA, NEW YORK AND THE APPLICANT'S RESPONSE

GLENS FALLS PROJECT
FISH ENTRAINMENT STUDY

<u>AGENCY COMMENT</u>	<u>APPLICANT'S RESPONSE¹</u>
1. NYSDEC suggested that the report describe that entrainment nets were pulled at 100% gate to increase efficiency.	Applicant agreed; additional measures implemented to increase efficiency will also be described.
2. NYSDEC suggested that the category "unknown fish remains" be further defined, to describe portion of the category with evidence of turbine damage. Recommended that this category also be assigned a fish value.	Applicant agreed to review the database to determine if the category could be further defined. Applicant also agreed to assign a fish value, based on average fish values of similar-sized fish. The Applicant believes, however, that a value of \$0 should be assigned to fish remains that were dead prior to entering the intake. Any value assigned to dead fish that had died from causes not associated with the project would overestimate the effects of the project.
3. The agencies recommended that mortality test results be reported as "instantaneous", "24-hour", and "48-hour" results, to be consistent with other ongoing New York State studies. Suggested that test conditions and problems with fish holding be explained in the report.	Applicant agreed to present results as recommended, although Acres pointed out that the results actually reflect mortality rates determined 24 hours, 48 hours, and 72 hours after fish are injected into the turbine intake. Test conditions and problems will be described in the report.
4. The agencies suggested that Table 4-7 (the fall 1993 efficiency/mortality test results) be labelled to indicate that test results were not used in the analysis.	Applicant agreed to footnote the table accordingly. The text already explains why the results were not used.

5. NYSDEC questioned whether dead fish efficiency tests results were included in the report, and whether these efficiencies were used in the entrainment estimates.

6. The USFWS stated that they did not agree with the American Fisheries Society (AFS) values for fish killed, which they believe were developed for one-time fish kills, not continuing mortality events. The USFWS indicated they would be developing alternative fish values.

7. Both agencies questioned the analysis in which the database was screened to exclude fish greater than one inch in width, to simulate the portion of the population that would be excluded by

These results are included in Table 4-8, Page 7. The results indicate an overall net efficiency of 86% with lower efficiencies in Unit 5. These lower efficiencies in Unit 5 are likely the result of hydraulic conditions in the tailrace at Unit 5 (the back eddy). Acres review of the entrainment calculations showed that a lower efficiency rate was used, but the calculations will be re-run using an 86% efficiency, for unknown dead fish only.

The Applicant acknowledges the USFWS disagreement with the AFS fish values, but believes the AFS values are appropriate for use in this analysis. The AFS is the professional society representing fisheries scientists throughout North America, including both agency and private sector scientists. Thus, the fish values developed by AFS should represent the most reasonable values, based on the best scientific and independent judgement of the AFS.

If the USFWS were to develop alternative fish values, the following should be considered:

- although hydroelectric projects may be a continuing source of mortality on a fish population, the compensatory reaction of fish populations should be considered (fish populations generally produce more individuals than can be supported by the local environment, and any "void" left by removal of some individuals would quickly be compensated for by replacement from the surplus); and
- the continued "harvesting" of fish by a hydro project is similar to the continued harvesting of fish by anglers, in that although some fish are killed, there are economic benefits to the community associated with this "taking" of fish;

The Applicant understands the agencies' concern related to this analysis, but has decided to keep this analysis in the final report, since it does provide useful comparative information on the potential benefits of fish

one-inch-spaced trashracks. They believed that such an analysis would underestimate the benefits of one-inch racks. The agencies stated that another study at an unspecified location had excluded in the range of 90% of the fish population. They recommended that the one-inch rack analysis be deleted since at Feeder Dam the comparison is between "actual" entrainment with 2¾ inch racks, and "theoretical" entrainment with one-inch racks.

protection measures. The analysis may underestimate the number of fish that would be excluded by one-inch racks, but it represents the best information available to quantify the potential benefits of these measures at the Feeder Dam and Glens Falls projects. To further explore this issue, however, additional analyses were conducted to determine the portion of the population that would be excluded by smaller spaced trashracks, based on measured fish widths.

The following summarizes the results of this analysis for entrainment at Feeder Dam.

<u>Rack Spacing (in.)</u>	<u>Estimated Annual Entrainment</u>	<u>% Reduction from 2¾ in. Spacing</u>
2¾	55,075 *	-
2½	54,934	0.25%
2¼	54,606	0.85%
2	54,434	1.16%
1¾	54,089	1.79%
1½	53,755	2.40%
1¼	53,667	2.56%
1	44,909	18.46%
¾	32,932	40.21%
½	28,361	48.51%
¼	11,993	78.22%

*This number represents only those fish for which width measurements were taken. Estimated entrainment cited elsewhere in the report includes some fish that were not measured for width.

This analysis indicates that, for the Feeder Dam database, few fish are physically excluded until the spacing reaches one inch, where 18.46% of the fish are excluded. Nearly 50% of the fish are excluded by ½-inch spacing, with the maximum exclusion of 78% occurring at ¼-inch spacing.

The agency-cited unnamed study with 90% exclusion at one-inch spacing may have little relevance to the Feeder Dam or Glens Falls

project results, since the species composition, size of fish tested, and other physical conditions (such as approach velocities), may be totally different from that at Feeder Dam or Glens Falls.

The above analysis will allow an order of magnitude assessment of the potential for underestimation of the benefits of one-inch-spaced racks, as presented in the report. For example, assuming that one-inch-spaced racks will actually exclude fish with widths as small as $\frac{1}{2}$ inch, 48.51% of the fish population passing the project would be excluded. If this occurred, the benefits of one-inch racks would be about $2\frac{1}{2}$ times greater than estimated for the one-inch analysis.

For the Glens Falls project, the database was similarly screened to remove fish with widths greater than $1\frac{5}{8}$ inches (41 mm) to simulate the exclusionary effect of the existing $1\frac{5}{8}$ -inch-spaced racks at Glens Falls. If the same logic is applied that this would underestimate the actual exclusionary effect of the $1\frac{5}{8}$ -inch-spaced racks, an analysis estimating that fish as small as one-half of $1\frac{5}{8}$ inches (i.e., $13/16$ ") would be excluded, would indicate the amount that the fish protection benefits of $1\frac{5}{8}$ -inch-spaced racks may be underestimated. Using the database as above, the following summarizes the analysis:

<u>Rack Spacing (in.)</u>	<u>Estimated Annual Entrainment</u>	<u>% Reduction from $2\frac{3}{4}$ in. Spacing</u>
$2\frac{3}{4}$	55,075	-
$1\frac{5}{8}$	53,996	1.96%
1	44,909	18.46%
$13/16^*$	37,125	32.59%
$\frac{1}{2}$	28,361	48.51%

*One-half of $1\frac{5}{8}$ inches.

This analysis indicates that the exclusionary benefits of the $1\frac{5}{8}$ -inch-spaced racks at Glens Falls could be underestimated by as much as $16\frac{1}{2}$ times (1.96% vs. 32.59% of the

population). In addition, if the "maximum" exclusionary effect of the 1½-inch and 1-inch-spaced racks are compared (i.e., fish half as wide as the rack spacing would be excluded), this analysis indicates that an additional 8,764 fish (about 24%) would be excluded with the installation of one-inch spaced racks (entrainment of 37,125 fish vs. 28,361 fish).

Applicant agreed to add this information on spring fish movements to the final report.

8. NYSDEC commented that the fish tagging data to verify net intrusion was interesting although it did not help in determining overall project impacts. NYSDEC suggested that information on observed spring movements of adult fish into the tailrace be included in the final report.

9. NYSDEC also questioned the statement in the report that the tagging data were treated conservatively, and suggested that net aversion may have occurred.

The Applicant continues to believe that the tailrace tagging data were used conservatively, in that only tagged fish were removed from the entrainment database, and were identified as net intrusion fish. Untagged individuals of the same species and size group, which were also believed to be net intrusion fish, were not identified as such, since a positive identification was not possible. This would overestimate entrainment. Net aversion was not believed to be occurring since the efficiency tests showed relatively high net collection efficiencies.

10. NYSDEC believed the relatively low efficiencies observed for small trout were the result of strong swimming ability as well as fish size.

Applicant agrees.

11. NYSDEC noted that more trout were caught in Unit 5 than in the other units, and questioned the reasons for this.

A possible reason is that fish accumulate in the tailrace back eddy near Unit 5 and enter the draft tube when the nets are set. Another reason for the apparent greater catch of trout in Unit 5 is that Unit 5 was sampled every event, while Units 1 and 3 were sampled on alternate events. The catch per effort of trout in Unit 5 (0.02 fish/hour) is higher than Unit 1 (0.003 fish/hour) or Unit 3 (0.004 fish/hour), but all three values for trout catch per effort are very low.

12. The agencies suggested that the final report include dividers between sections of the report.

Applicant agrees.

13. The agencies questioned the data manipulations required to develop the mortality adjustment factor for the Glens Falls project (to adjust mortality rates determined at the Feeder Dam project for use at the Glens Falls project). They suggested that the data from the 1990 RMC turbine mortality study at Glens Falls be used directly, in the calculation of the adjustment factor.

The Applicant agreed to further review the RMC results and to directly use these results in the calculation of the mortality adjustment factor. The final report has been revised accordingly, using a mortality conversion factor of 2.32, rather than the 1.49 conversion factor used in the draft report.

14. The agencies recommended that entrainment estimates at the Glens Falls Project assume a 50%-50% flow sharing between the Glens Falls and South Glens Falls projects. The fish per volume of flow determined at Feeder Dam (after screening for 1½-inch-spaced racks) could then be applied to 50% of the flow passing Glens Falls, to estimate entrainment.

The Applicant agreed to recalculate the entrainment estimate at Glens Falls as the agencies had recommended. The final report has been revised accordingly.

15. The agencies indicated that they had not yet reached a consensus on the significance of entrainment impacts at the Feeder Dam and Glens Falls projects, and on the need for fish protection. This consensus would likely be reached at the conclusion of the FERC EIS process.

This comment was noted.

¹ The Applicant's responses included herein are a combination of the responses provided to the agencies at the meeting and responses developed since the meeting.

7 LITERATURE CITED

- Acres International Corporation. 1993. Report on Fishing Investigations to Answer FERC Additional Information Requests. Prepared for Finch, Pruyn and Company, Inc. and Moreau Manufacturing Corporation. December 1993.
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- RMC Environmental Services, Inc. 1990. Turbine Survival of Fishes at the Finch, Pruyn Hydroelectric Project, Glens Falls, New York. Prepared for Finch, Pruyn and Company, Inc. September 11, 1990.